UNIVERSIDAD CARLOS III DE MADRID

Tesis Doctoral

Contemporary Challenges in High- Tech Innovative Strategy: Technological Collaboration, Product Diversification, and Organizational Innovative Productivity

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TESIS DOCTORAL

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Getafe, de de

A Andrés, a mis padres, y a mi hermano

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RESUMEN EN CASTELLANO

Esta tesis analiza los actuales desafíos de la estrategia de innovación en industrias tecnológicas de acuerdo a diferentes enfoques tecnológicos y de mercado. El objetivo de este estudio es construir una perspectiva innovadora contemporánea recurriendo a los orígenes del desarrollo de intercambios tecnológicos, fuentes tecnológicas de la estrategia de diversificación de productos y determinantes de la productividad en la actividad innovadora. Todos los artículos son analizados empíricamente gracias a la elaboración de una base de datos original de 102 empresas innovadoras (seleccionadas a través de Fortune 500, 2006) procedentes de 8 sectores diferentes que cubren el periodo de 1999 a 2005.

El Capítulo I de este proyecto se centra en el estudio de los efectos de mecanismos de competencia multimercado en la reconfiguración de los supuestos de modelos de innovación abierta. Intentamos superar los límites de la investigación tradicional en innovación mediante la reconciliación de dos modelos teóricos que en un principio pueden parecer opuestos. La meta de esta investigación es proporcionar un nuevo razonamiento sobre el papel de contactos multimercado en el desarrollo de intercambios tecnológicos de innovación abierta. Concretamente, analizamos si la adopción de un modelo de competencia multimercado refuerza tradicionales mecanismos de amenaza, o en cambio, fomenta la innovación abierta en sectores tecnológicos. Demostramos una relación curvilínea entre el número de contactos multimercado y el desarrollo de intercambios tecnológicos. Además ofrecemos

evidencia empírica de la función del stock de patentes de una empresa como moderador positivo en la relación entre el modelo de innovación abierta y el modelo de competencia en multimercados.

El Capítulo II examina el impacto de acuerdos contractuales de I+D, en la estrategia de diversificación de productos que realiza una empresa En concreto, proponemos modelos de innovación abierta para entender la estrategia de diversificación de productos. Este estudio analiza cómo el desarrollo de acuerdos contractuales de I+D (alianzas estratégicas y compra de licencias) pueden ser fuente de diversificación de productos. Además, profundizamos en esta exploración mediante el análisis de la estructura del stock de conocimiento actual como mediador clave. Los resultados confirman un impacto positivo de las alianzas estratégicas en la diversificación de productos. También se encuentra evidencia empírica del papel de la integración del conocimiento como mediador positivo entre alianzas y penetración de mercados. Por otro lado, la integración de conocimiento actúa como moderador negativo cuando consideramos el efecto de la adquisición de licencias en la diversificación de productos.

Finalmente, el Capítulo III explora como la diversificación organizacional (diversificación ascendente y diversificación descendente), afecta a la productividad innovadora de la organización. Contribuye a la literatura de Utilizamos la teoría de diversificación para comprender la productividad en la estrategia de innovación desde dos ámbitos diferentes (productividad de conocimiento y de introducción de productos). Este artículo examina la influencia de la diversificación de mercados y la diversificación tecnológica, en la capacidad organizativa de introducción de productos y en la productividad en la búsqueda tecnológica. Demostramos que la diversificación ascendente disuade a las empresas de introducir productos. En cambio, la diversificación descendente alienta la adopción de conocimiento.

INTRODUCTION

How do high-tech firms develop an effective innovation strategy nowadays? In this dissertation I address this question in three essays that adopt different product-market and scope

Innovation has been broadly explored trough different research streams, however innovation literature has not provided a contemporary perspective according to current organizational and market characteristics. The rules of the market game have changed, firms have to adapt to the new open environment characterized by quick changes, and firm´s ability to identify business opportunities become essential for organization survival. We acknowledge that to accomplish high tech market necessities, firms must balance its capacity to develop know-how and their ability to diversify into new markets through the introduction of new products. Firms involve in schumpeterian competition, must adapt to rapidly evolving industries, where competitive capabilities are transitory, and opportunities are quickly closed by competitors (Kim & Kogut, 1996). Innovations in such environments quickly erode and firm must be aware to obtain relevant knowledge in order to develop efficient innovations to explore new markets. Technological collaboration across firms emerges as essential organization strategy, in order to obtain higher performance rates and develop the most efficient technology. Open Innovation explores the capacity of firms to collaborate each other through technological agreements, letting ideas both flow in and out of the corporation based on a dynamic in/out contractual activity (Chesbrough, 2003). Open Innovation paradigm, balances in the same way the internal firm capacity and the external market players ability, in order to develop a stronger competitive position based on the exploitation of internal and outside competitor's knowledge which cannot be developed inside the company.

This dissertation attempts to overcome this traditional research gap through three essays, which address a sequential contemporary innovative perspective drawing on open innovation models, diversification theory, organizational knowledge structure, and product innovation theory. The central aim of this thesis is to understand innovation strategy through a comprehensive analysis from the origins to the implications of innovation strategy in high-tech industries. Specifically, we explore innovation dynamics from the management of innovation sources to the achievement of organizational innovative productivity.

The beginning of my dissertation explores the birth of innovation strategy in high-tech industries through market structural characteristics. I study firm´s capacity to develop open innovation technological exchanges, by examining organizations multimarket contacts. Once pointed out the origins of innovation, this research goes on providing a new understanding of product diversification theory. The second essay focuses on technological sources as enactors of product diversification strategy. The study shows the impact of R&D contractual agreements in organizational ability to introduce new products. Finally, the thesis addresses the last stage of innovation strategy analysis by exploring diversification latest implications in organizational innovative productivity. The third essay, builds on diversification theory to look into productivity implications of innovative strategy. Specifically, the research reports the effects of organizational diversification on product and knowledge productivity.

The empirical testing of the propositions developed in the three essays relies on a single database that was specifically developed for this dissertation. The first step in building this database was to create a complete and reliable panel data for high tech organizations. We rely in two main criterions in order to select the database companies. Firstly, according to the “globalization era”, due to the chance to operate in different markets, geographical borders have not sense, and we select multinational companies. Therefore, our sample is composed by large international companies because they operate in different markets of products with several overlaps. A second selection criterion is focusing on high tech sectors in which the development of innovation strategy is a key factor in order to achieve a sustainable competitive advantage. We identify large companies through Fortune Global 500 2006. Fortune Global 500 2006, present the list of largest world companies classified into 52 sectors. Among these 52 sectors, we identify high tech sectors through Compustat database, looking for R&D overall sector expenses. The sectors selected are the following: aerospace and defense, chemicals, computer & office equipments, electronics & electrical equipment, motor & vehicle parts, pharmaceutical, semiconductors and telecommunications. The database generates 714 observations on 102 companies classified into 8 different industries from 1999 to 2005.

Once the selection of our database companies was completed, I gathered data on diverse innovative key events from InfoTrac database. InfoTrac is a database of magazine and journal indexes, (including 1,700 full text magazines). The database contains index entries, abstracts, and in most cases the complete articles from magazines and journals. In order to get core innovative events for the research, we perform an event classification, searching for all articles that reported the name of the company (Fortune R&D companies) and the concepts “licensing agreements”, “strategic alliances” and “product introduction” from 1999 to 2005.

After this initial classification, we read all the articles in order to filter technological exchanges to obtain the number of R&D technological licenses and R&D strategic alliances. Then, from each of these articles we extract the date of technological agreement, the name of the companies involved, and the number of licensing agreements and strategic alliances over time. In the case of events codified as “product introduction”, we extract the name of the company, the date of product introduction, the number of products introduced yearly by each company, and the line of business object of product introduction (four digits SIC code). We select SIC code criterion to identify the markets in which firms introduce a product, thus the markets object of entry by firms.

The use of InfoTrac database allowed me to build a first competitive database in order to test our studies. However, the original database was enlarged by the sequential introduction of new variables according to our research demands. For variables related to knowledge structure characteristics, knowledge diversification and business diversification, we find useful information from NBER and USPTO databases.

In Chapter I of this project, we focus on how multimarket competition mechanisms reconfigure assumptions of Open Innovation (OI) model. This paper supposes an important challenge in the research of firm’s sources of innovation. We try to overcome traditional boundaries in the research of innovation activity trough the reconciliation of two theoretical models which can be considered opposite. The aim of this research is to provide a new understanding of the role of firm's multimarket contacts in the creation of OI technological exchanges. We address if the firm's adoption of a MMC model represent a traditional forbearance mechanism or that such contacts encourage OI activity in high-tech environments. We find that multimarket contact is curvilinear (taking an inverted U-shape) related to technological exchanges development. We also offer empirical evidence for the role of firm´s patents stock as a positive moderator in the MMC-OI relationships.

Chapter II examines how R&D contractual agreements impact on product diversification strategy. We built on Open Innovation business models to understand Product Diversification strategy. This study examines how the development of different R&D contractual agreements (strategic alliances and licensing-in agreements) can be source of product diversification. This study goes further in this exploration through the study of current knowledge portfolio configuration as key mediator. We find that strategic alliances have a positive impact on product diversification. We also offer empirical evidence for the role of firm´ s knowledge integration as a positive mediator between alliances and market penetration. On the other hand, knowledge integration acts as negative moderator when we consider the use of licensing-in agreements in product diversification.

Finally, Chapter III explores how both upstream and downstream diversification impact on organizational innovative productivity. We built on diversification theory to understand innovation strategy from two different scopes (product and knowledge productivity). This study examines the influence of business and technological diversification on firm’s ability to introduce new products and knowledge search productivity. We find that upstream diversification discourages product introduction.

On the other side, downstream diversification supports the adoption of new knowledge.

CHAPTER I

Multimarket Contact Challenges in Open Innovation Environments

ABSTRACT

In this article we focus on how multimarket competition mechanisms reconfigure assumptions of Open Innovation model. The reconciliation of both schemes gives the opportunity to develop the Open Innovation innovative pattern taking into account Multimarket Contact paradigm. This study examines how the development of multimarket contact can be source of technological exchanges. Our hypotheses are tested through an intra-industry analysis finding that multimarket contact is curvilinear (taking an inverted U-shape) related to technological exchanges development. We also offer empirical evidence for the role of firm's patents stock as a positive moderator in the MMC-OI relationship.

Keywords: Open Innovation, Multimarket Contact, high-tech industries.

Multimarket Contact Challenges in Open Innovation Environments

Introduction

This paper supposes an important challenge in the research of firm's sources of innovation. We try to overcome traditional boundaries in research of innovation activity trough the reconciliation of two theoretical models which can be considered opposite. Our goal is to explain Open innovation activity through the application of MMC theory. This research explores the multimarket contact implications on the creation of Open Innovation technological exchanges. Multimarket Competition Theory has been an interesting field of research over time, due to its important implications on competition and firm performance. Multimarket competition gives firms the opportunity to reconfigurate the market game through the control of rival's movements. Research in Multimarket competition, has analyzed the role of multimarket contact (MMC) and strategic diversion in markets characterized by high levels of mutual control and protection (Gimeno & Woo, 1996; Boeker, Goodstein, Stephan, Murmann, 1997; Gimeno, 1999; Grimm, Simon, Smith, Young, 2000; Fuentelsaz & Gómez, 2006).

MMC has been analyzed in extreme closed environments; such environments have been characterized by high collusion rates. At this point it would be interesting to analyze the role of MMC in environments characterized by high levels of competition. Open Innovation business models explores the capacity of incumbents to collaborate each other through technological exchanges (Chesbrough, 2003). The question would be if the application of MMC mechanisms would influence on OI activity. It would be necessary to explore the new role of forbearance mechanisms.

The aim of this research is to provide a new understanding of the role of firm's multimarket contacts in the creation of OI technological exchanges. We address if the firm's adoption of a MMC model represents a traditional forbearance mechanism or encourages OI activity in high-tech environments. We test the effects of MMC on OI using a sample of 102 Fortune high-tech firms from 1999 to 2005. We find that firms who have an intensive multimarket activity develop more OI technological exchanges. However, we find that the impact of MMC on the creation of technological exchanges are subject to decreasing rates, indicating that there is a point where additional MMC becomes detrimental for OI exchanges. Moreover we find out the role of firm's patent stock as a positive moderator in the MMC-OI relationship.

Several contributions stem from this research. First, it deepens our understanding of sources of innovation activity. We analyse OI assumptions from a new perspective realizing about the current market conditions, and propose an innovative pattern. Research on open innovation has been focused on cooperation assumptions derived from markets with high level of competition. We enlarge OI research scope taking into account MMC effects (considered as traditional collusion mechanisms) in the development of cooperation exchanges. At our concern, there is not previous research matching MMC framework with Open Innovation business models.

Another gap we try to challenge is the one related to the empirical validation of multimarket models. Over time research in MMC has been tested empirically in markets which exhibit a clear geographical delimitation (Gimeno, 1999). Nowadays according to the "globalization era", firms develop their business in a large number of countries. Due to the chance to operate in different countries, geographical borders have not sense. We propose to test the model in the largest multinational companies, according to a product-niche analysis.

The paper is organized as follows. In the next section we present a literature review of MMC and OI framework. Then we develop the critical questions of our study, we explore the effects of MMC adoption in OI environments. After developing the research questions, we describe the sample and the measures we use in the analysis. Finally the last two sections present the results and the conclusion of the study.

Theoretical Background

Multimarket competition (MMC) involves the mutual competition of different firms in same markets, with same product lines (Edwards, 1955; Gimeno, 2002; Vannoni, 2004).

MMC framework suggests that firms collude as result of cross-market relationship and the development of mutual retaliation mechanisms (Gimeno & Woo, 1996; Gimeno, 2002). Retaliation mechanisms imply high degree of commitment among firms according to mutual forbearance theory.

Multimarket contact reflects the number of markets in the industry in which the same pair of firms meet as competitors (Gimeno & Woo, 1996). Increasing the number of markets requests in which firms compete would reduce competitive behaviour. Firms that are interdependent in multiple markets are more likely to engage in mutual forbearance and lower competition. The logical consequence is the reduction of rivalry intensity.

Traditionally, literature on multimarket competition focuses in closed environments with high collusion rates. Multimarket theory explores the following research patterns: MMC and strategic resource diversion effect on rivalry intensity (Gimeno & Woo, 1996; Grimm et al.2000), MMC and competitive structure behaviour (Boeker et al. 1997; Fuentelsaz & Gómez, 2006), MMC impact on different market conditions (Gimeno, 1999), firms motivation to develop MMC (Baum & Korn, 1999), MMC final effects on firm performance (Gimeno & Woo, 1999).

Recently, Open Innovation Business Model emerges as a new model developed by Chesbrough (2003), with origin in a previous analysis of innovation sources (Von Hippel, 1988). According to OI framework, large high tech firms develop collaborative strategies in order to obtain higher performance rates and develop the most efficient technology. This new theory explores the capacity of incumbents to collaborate each other through technological exchanges, letting ideas both flow out of the corporation in order to find better sites for the innovation monetization, and flow into the corporation as new offerings and new business models (Chesbrough, 2006). Technological exchanges are based on a dynamic in/out licensing activity. The application of OI business models implies high levels of competition due to the opportunity to enter into different markets.

Open Innovation paradigm, balances in the same way the internal firm capacity and the external market players ability, to develop a stronger competitive position based on exploitation of internal and outside competitor's knowledge which cannot be developed inside the company. The combination of internal and external ability to innovate, suppose a challenge respect to traditional theories such as Absorptive Capacity Theory. Absorptive Capacity focuses on the role of internal firm capacity to create knowledge, and highlights the capacity of the firm to identify and assimilate external knowledge (Cohen & Levintahl, 1990). The creation of sustainable competitive advantage in Absorptive Capacity Theory relies on the internal firm capacity to absorb external knowledge, and the successful adaptation inside the firm. Absorptive Capacity Theory explores the internal sources as enactors of value creation, through the internal firm ability to exploit internal valuable resources, or through the internal ability to assimilate external knowledge.

At first sight it would not be clear to assume an Open Innovation business model in a multimarket competition environment, because these schemes rely on different objectives and different assumptions. OI encourages industry competition through trust, and information exchange. On the other hand, multimarket framework develops threats and retaliation mechanisms to avoid new competitor's entry. It would be concluded that traditional mutual forbearance mechanisms would not work in open business models.

The incumbents in MMC look for opportunities to reduce industry competition. Research identifies those strategies in industries in which incumbents exhibit high levels of market overlap. Market overlap implies firm competition as direct rivals in different markets segments. Incumbents decide to collude in order to prevent the entrance of potential rivals, looking for competition reduction.

In order to define the real role of R&D collaborative agreements, we must explore MMC and OI assumptions. We have to look for a link in order to reconciliate both schemes. Multimarket competition theory develops its main hypothesis around multimarket contact and development of retaliation mechanisms. Multimarket contact is based on firm's capacity to enter into different markets. Diversification strategy would enlarge the number of markets in the industry in which the same pair of firms meet as competitors. Multimarket contact would be the natural consequence of diversification strategy.

On the other hand, OI presents technological exchanges as the major driver of the model. The development of technological exchanges among different market players would imply penetration in new markets. Thus, technological exchanges in Open business models would encourage diversification strategy.

At this point, the key point would be to explore the motivation of multimarket firms to perform technological exchanges. Once we point out this motivation, we could predict innovative strategic behaviour patterns in multimarket industries. In the next section we present the three hypothesis object of our study.

Hypotheses

The adoption of MMC mechanisms encourages firm's introduction into new markets, supporting diversification strategy. OI assumes the positive impact of technological exchanges on new markets penetration. Due to diversification has a positive impact on technological exchanges, multimarket contact would reinforce OI exchanges. It is necessary to explore the forbearance mechanisms implications on OI business models.

Multimarket competition forbearance mechanisms implemented in Open business models environment involve different assumptions according to the market object of retaliation. If one firm realizes about a competitor attack in its core business, the threatened firm could develop two different strategies based on the technological exchange role of forbearance strategic actions. We can define a first strategic reaction as "Direct response strategy" in order to protect its core business from rival's threaten. We define a second type of strategic reaction as "Indirect forbearance strategy" and would suppose to attack rival's core business market.

Firms which follow the Direct Response Strategy would protect directly its core business from competitor's entry through the implementation of dominant Open Innovation technological exchanges. The aggressive entry of a new competitor would damage the original incumbent benefits. The original incumbent would try to develop collusion agreements in order to minimize potential looses. Collusion agreements would imply firms cooperation supporting an energise in and out technological exchanges in its core market.

Another retaliation mechanism developed by a firm in order to protect its core business is the "Indirect forbearance strategy". This indirect strategy would be result of asymmetric interest's implications. Due to the existence of a competitor core business there is a chance for a potential reciprocal response. The initial threatened firm would develop retaliation mechanism in the core rival's market, in order to abort the rival's attack. The leader firm in the attacked market would respond improving its weak position in the rival's core business through OI exchanges.

The company would increase the entry in the rival's market by licensing technology to competitors. This strategy does not imply a direct entry in the rival's market, but it makes enter others competitors by licensing.

In order to go into MMC-OI relationship in depth we provide two related reasons why MMC has a positive influence on the development of OI technological exchanges. First, we explore the multimarket contact role as trust reinforcement mechanism. As long as firms develop more multimarket contacts, the level of collusion arrangements increases to control the entrance of potential rivals. Collusion arrangements developed by incumbents would reinforce trust across them. Trust would increase the willingness to cooperate to dominate the market, threaten to be damaged by the rival would be lower and firm's motivation for technological exchange would increase. Second, we must realize about the MMC impact on technological uncertainty. When firms perform their activity in different markets (with any multimarket contact), the success of the technological exchanges faces a high uncertainty level due to the potential technological incompatibilities across markets. As long as firms develop more multimarket contacts, they share a similar market structure, companies increase the chance to select the successful technology and feel more confident to develop efficient technological exchanges.

At this point, we present the first research question of the study. We would expect that the development of multimarket contact would reinforce Open Innovation strategic behaviour.

Hypothesis 1: "The higher the firm's level of MMC, the larger will be the number of OI technological exchanges developed by a firm"

However, the relationship between MMC and technological exchanges would not be linear. Multimarket competition literature posits that as the number of contacts grew, information on rival's strategic behaviour (strategic familiarity) and the recognition of the interdependencies and of the capacity of harming the rival (strategic deterrence) would foster mutual forbearance (Fuentelsaz & Gómez, 2006).

We present three mechanisms to support the existence of quadratic effects in the MMC-OI relationship. First, too intensive MMC activity would encourage strategic deterrence. According to our study, MMC below a certain threshold would have a positive influence on the number of firm's technological exchanges through its role as retaliation. However, when firms develop an intensive multimarket activity the number of common markets grows up, and the chance to match with rivals in company's core market will rise. If the number of potential competitors increases in each market, incumbent's potential benefits will decrease. Thus, competition across firms will come up, firms will stop cooperation, and companies will reduce OI exchanges. The second reason analyses the emergence of technological differentiation hindrance. When firms perform more multimarket contact, the number of common markets across firms will be larger. Firm's market differentiation will not be significant due to similar firm's competitive market structure. As long as companies will face the same environment (opportunities and threatens), firms will be more likely to develop similar technological innovations. If firms do not perceive the existence of valuable external technologies, companies will be deterred from performing OI exchanges. Third, we present one more mechanism related to the attention allocation problem. Managerial attention is the most precious resource inside the organization and that the decision to allocate attention to particular activities, decision makers need to concentrate their effort in a limited number of issues (Laursen & Salter, 2006). When firms perform an intensive multimarket activity there are so many markets object of technological exchange, according to attention allocation problem, few of these potential technological exchange are taken seriously or given the required level of attention to bring them into implementation. Due to managers will decide to concentrate their attention in a limited number of markets; the potential number of technological exchanges will be lower as long as

MMC activity increases. Therefore, we can predict a quadratic relationship between MMC and OI technological exchanges.

Hypothesis 2: "MMC has an inverted U-shape influence on OI technological exchanges"

In the attempt to develop new technologies and perform technological exchanges firms draw upon their stocks of knowledge to integrate and improve upon outside technologies (Kogut & Zander, 1992; Helfat, 1994; Ziedonis, 2004). Literature posits that a dynamic in/out licensing activity is one of the main hypotheses in the Open Innovation model (Chesbrough 2006). Due to our purpose is to test the capacity of MMC to generate open innovation technological exchanges; we should explore the role of the stock of knowledge accumulated by firms.

In order to understand the role of the patent's stock on MMC-OI relationship we provide three arguments. First, firms which achieve a large stock of patents develop a high level of absorptive capacity. As long as companies are used to acquire external knowledge, they increase the ability to absorb external knowledge and create mechanisms for its successful adaptation inside firms. Due to OI exchanges imply the use of external knowledge; the absorptive capacity will motivate firms to develop more technological exchanges across firms. Second, large patent portfolios improve bargaining position. When a firm acquire technology from outside, it increase its ex-post bargaining position to create a de facto "exchange of hostage" in order to avoid rent expropriation from patent owners (Ziedonis, 2004). The improvement of the bargaining power allows firms to minimize risk in future negotiations and encourages firms to reinforce cooperation through the development of OI technological exchanges. Third, an active patent activity supports the creation of an interactive pattern. The development of technological contacts between companies implies information exchange across competitors (original patent holders). The information exchange allows the creation of an interaction pattern which generates trust across firms, guarantee security in the exchange, and support the technological exchange over time. We could predict that patents stock would be a positive moderator in the relationship between multimarket contact and open innovation technological exchanges.

Hypothesis 3: "The effect of MMC on OI technological exchanges will be more pronounced among firms with higher stock of patents"

Methods

Data and Sample

Multimarket Competition theory examines industries which exhibit high degree of market overlapping. Over time, literature have explored multimarket contact implications trough a geographical market division. According to the current international context we are going to perform a product market division. At our concern, product niche division has not been empirical tested in Multimarket Competition theory. We must look for large companies which operate in different markets source of mutual threaten. Our first criterion is going to consist of the selection of world large companies.

On the other hand OI examines the strategic behaviour and innovation pattern in high R&D markets. In order to create a valid and robust model, the second criterion is the selection of high tech companies.

We identify large companies through Fortune Global 500 2006. Fortune Global 500 2006, present a list of industries, in which companies are classified into 52 sectors. We have to select firms which develop an intensive technological activity to forecast OI business models.

We identify high tech sectors through Compustat database. We look for R&D overall sector expenses. We have to sum the overall R&D company expenses of the group of firms which belong to the same sector. The sectors selected are the following: aerospace and defense, chemicals, computer & office equipments, electronics & electrical equipment, motor & vehicle parts, pharmaceutical, semiconductors and telecommunications. The sample generates 714 observations on 102 companies classified into 8 different industries.

Measures

Dependent variable

Open Innovation variable is related to the number of technological agreements among firms from 1999 to 2005. We extract this data from InfoTrac Database. InfoTrac is a database of magazine and journal indexes, (including 1,700 full text magazines). The database contains index entries, abstracts, and in most cases the complete articles from magazines and journals. In order to look for technological exchanges, we search for all articles that reported the name of the company (Fortune R&D companies) and the concepts “licensing agreements” and “strategic alliances” from 1999 to 2005. After this initial classification, we read all the articles in order to filter technological exchanges to obtain the number of R&D technological licenses and R&D strategic alliances. Then, from each of these articles we extract the date of technological agreement, the name of the companies involved, and the number of licensing agreements and strategic alliances over time.

Open Innovation technological exchanges measure the number of technological exchanges (sum of strategic alliances and licensing agreements) between firm *i*, and firm *j* over time.

$$\sum \text{Technological Exchanges}_{ijt} = \sum_{j \neq i} \text{Strategic Alliances}_{ijt} + \sum_{j \neq i} \text{Licensing Agreements}_{ijt}$$

Independent variables

The goal of our study is to analyze how the level of multimarket contact across firms is going to influence company's technological exchanges. Literature presents debate about the measurement of multimarket contact variable (Gimeno, 1999). In order to avoid the lack of consensus, the paper uses a simple count measure of multimarket contact (Gimeno & Woo, 1996). MMC variable represent the number of markets in which the same firms meet as competitors from 1999 to 2005. We obtain the data through Info Trac Database. We take into account the list of Fortune R&D firms in order to develop the database. We perform an event classification; we search for all articles that reported the name of the company and the concept "product introduction". We extract the name of the company, the date of product introduction and the line of business object of product introduction (four digits SIC code). We select SIC code criterion to identify the markets in which firms introduce a product, thus the markets object of entry by firms. After this initial classification we proceed to make operative the MMC variable calculating the number of markets (SIC codes) in which different firms meet as competitors over time.

An instance of MMC occurs when a firm *i*, an incumbent in a focal market *m* (a certain SIC code) and another competitor *j* in market *m* meet in another market *n* (a different SIC code from the previous one) in which competitor *j* is an incumbent and firm *i* is an incumbent or potential entrant. That instance is coded as $MMC_{ij, mn,t}=1$.

The multimarket contact of firm *i* with competitor *j* is the sum of multimarket contacts over all markets outside market *m*. In order to define in the correct way MMC variable, we have to realize about the influence of the number of competitors in each market (SIC code) on the number of multimarket contacts developed by each firm (Gimeno & Woo, 1996).

$$MMC_{ijmt} = \frac{1}{\text{Total Competitors}_{imt}} \sum_{j \neq i} MMC_{ijmt}$$

We need to introduce patent stock as another independent variable. Patent stock controls for firm's level of protection against competitors. We find out the information through the United States Patent and Trademark Office (USPTO). The role of the USPTO is to grant patents for the protection of inventions and to register trademarks. It serves the interest of inventors and businesses with respect to their inventions and corporate products, and service identifications. We report the total number of patents of each firm from 1999 to 2005.

Control Variables

In addition to the variables proposed to test the hypothesis, we also control for other factors suggested by the multimarket competition, OI, and patents literature.

We consider the following firm control variables: return of investment (ROI), market value, firm size. Firm's performance variable we select is ROI measurement in order to control for the firm's economic efficiency on the development of OI exchanges. Market value concept returns the market value as of the company's fiscal year end. Firm size represents the firm's volume of net sales. We obtain these variables from 1999 to 2005 through Compustat database.

The analysis of OI business models calls for the introduction of another group of control variables related to innovative capacity of the firm: firm's trademark stock and firm's R&D expenses.

Trademark stock help companies to protect from competitors, we include this variable to control for intellectual property which is not related with technological innovation and avoid biases in the measurement of technological exchanges. We obtain this variable through USPTO.

R&D expenses control for the ability of each firm to invest on innovation activity. We compute R&D expenses variable for all the companies from 1999 to 2005 through Compustat database.

Finally we include three groups of dummy variables: nationality, the sector, and the year object of study. We have to control the nationality of the firm in order to realize about the influence of the firm's origin on the results. We define 12 dummy variables according to our firm's nationality (USA, UK, Canada, France, Japan, South-Korea, Netherlands, Germany, Sweden, Italy, Switzerland, and Spain). The second group of dummy variables controls for sector characteristics to avoid the impact of industrial innovation capacity on the regression. We obtain 8 sector dummy variables according to Fortune high tech sectors classification (aerospace and defense, chemicals, computer & office equipments, electronics & electrical equipment, motor & vehicle parts, pharmaceutical, semiconductors and telecommunications). Moreover we need to control for the year object of study to avoid the influence of macroeconomic trends such as economic cycles and periods of technological ferment that could affect technological exchanges. Due to our analysis study the impact of MMC on OI exchanges from 1999 to 2005, we have 7 year dummy variables.

Table 1 reports the descriptive statistics for our analysis of multimarket mechanisms effects on open innovation technological exchanges.

If we look at our core variables values in Table 1 we can see that on average, a firm performs 2,18 multimarket contact by year, with a maximum value of 58 multimarket contacts and a minimum value of 0. As shown in Table 1, Open Innovation variable, on average a firm develops 5,18 open innovation technological exchanges by year, the most active firm develops 76 exchanges, and the most passive firm 0 exchanges.

Table 1. Descriptive Statistics and Correlation Matrix

Variable	Obs.	Mean	Std. Dev.	Min.	Max.	OI	Mmc	Mmc Squared	ROI	Net Sales	Market Value	Patents	Trademarks	R&D Expenses
OI	714	5.19	8.47	0.00	76.00	1.00								
Mmc	714	2.18	6.31	0.00	58.00	0.51	1.00							
Mmc Squared	714	44.56	216.15	0.00	3364.00	0.35	0.91	1.00						
ROI	714	8.14	15.05	-75.22	247.00	0.09	-0.06	-0.07	1.00					
Net Sales	714	36709.55	34768.39	0.00	200914.80	0.10	0.17	0.16	-0.05	1.00				
Market Value	714	47255.13	64349.99	0.00	905468.00	0.22	0.01	0.00	0.22	0.12	1.00			
Patents	714	271.29	474.85	0.00	2312.00	0.37	0.52	0.29	-0.05	0.17	-0.05	1.00		
Trademarks	714	36.92	58.13	0.00	548.00	0.29	0.19	0.15	0.09	0.23	0.09	0.21	1.00	
R&D Expenses	714	1753.26	2192.66	0.00	33137.52	0.21	0.20	0.17	0.02	0.42	0.20	0.21	0.27	1

Results

Table 2 reports a robust linear analysis for our study of MMC in an Open innovation setting. Model 1 supports Hypothesis 1 as long as MMC would be higher, the number of OI exchanges will increase. This model is globally significant, confirming the positive influence of MMC on OI exchanges. In this table we confirm the relevance of patents and trademarks. Due to these high values we can sense the existence of a multiplicative effect between MMC and patents and trademarks.

Hypothesis 2 posited the existence of a quadratic effect in the MMC-OI relationship. Model 2 finds strong support for the hypothesis asserting the existence of quadratic effects of MMC on the development of OI exchanges-taking an inverted U-shape-. First, the parameter for MMC is positive and significant for the development of OI technological exchanges. Second, the parameter for Mmc Squared is significant as well, but it takes a negative coefficient.

The existence of quadratic effects implies that when firm develops too many multimarket contacts, there is a reduction in the number of OI technological exchanges. Trademarks, R&D expenses control variables and dummy variables (sector, year and nationality) are significant in the robust test performed in Model 2- On the other hand, stock of patents is not anymore a significant variable in this new model.

In order to go deeper on the analysis of the MMC-OI relationship we perform a simulation test to predict a reliable behavior of our variables. We predict the value of the OI dependent variable according to the coefficient modification of the control and independent variables (MMC and stock of patents). We perform the variables coefficient modification as follows, we multiply each control variable coefficient variable by its mean value, and we multiply the independent variable coefficients by a range of values (from its minimum to it maximum score).

Table 2. Linear regression, explaining MMC impact on OI technological exchanges.

Independent variable	Model 0	Model 1	Model 2	Model 3
Mmc	-	0.47***	1.31***	1.09***
		-0.11	(0.19)	(0.26)
Mmc Squared	-	-	-0.02***	-0.02***
			(0.00)	(0.01)
Patents	-	0.00***	0.00	-0.00
		(0.00)	(0.00)	(0.00)
Mmc * Patents	-	-	-	0.00**
				(0.00)
ROI	-0.02**	0.00	0.00	0.00
	(0.01)	(0.01)	(0.01)	(0.01)
Net sales	0.00	0.00	0.00	0.00
	(0.00)	(0.00)	(0.00)	(0.00)
Trademarks	0.02***	0.01***	0.01***	0.01***
	(0.01)	(0.00)	(0.00)	(0.00)
R&D Expenses	0.00*	0.00*	0.00*	0.00*
	(0.00)	(0.00)	(0.00)	(0.00)
Market value	0.00*	0.00*	0.00	0.00
	(0.00)	(0.00)	(0.00)	(0.00)
Dummy Sector		yes		
Dummy Nationality		yes		
Dummy Year		yes		
F(32, 681)	13.90	17.97	18.84	18.62
Prob > F	0.00	0.00	0.00	0.00
R-squared	0.41	0.52	0.56	0.57
Root MSE	6.63	5.98	5.74	5.71

One-tailed *t*-test applied.

* p < 0.10

** p < 0.05

*** p < 0.01

Due to MMC takes a range of values from 0 to 58 multimarket contacts, we select a range from 0 to 60 for our MMC variable in the simulation. On the other hand stock of patents variable takes values from 0 to 2312 patents, we select an interval value from 0 to 2400 for the patents variable in the simulation. Finally we perform different regressions in order to predict OI technological exchange behavior according to the different values selected.

In Table 3, we confirm the inverted U-shape relationship between MMC and OI. We find interesting results. First, as long as MMC and patents stock increase, the number of OI rises as well. Second, as long as firm´s stock of patent increase (and MMC remains constant), firm develops more OI technological exchanges. Third, when firms select a high score range of multimarket contact (from 30 MMC to 60) and patents remains constant, the level of OI decrease. OI variable reaches its higher score with a value of 30, 81 technological exchanges, this value is the result of 40 multimarket contacts and 2400 firm´s patents (the highest level of patent stock). The lowest score of OI is -1,58 technological exchanges, firms get this result when develop 60 multimarket contact (the highest value of multimarket contact) and 0 firm´s patent (the lowest level of patent stock).

Our investigation about the influences of MMC on OI continues in Table 2. Model 3 focuses on the test of Hypothesis 3 in order to find out the existence of a moderator in the MMC-OI relationship. The interaction between MMC and patents (Mmc*Patents) has a significant positive impact meaning that the effect of MMC on OI exchanges becomes more intense as firm´s patent stock is higher. The hypothesis affirming the existence of a quadratic MMC-OI relationship finds strong support as well. Of our control variables, the parameters for trademarks, R&D expenses, and dummy variables (sector, year and nationality) are consistently positive and significant in explaining the relationship between MMC and OI technological exchanges.

Table 3. Simulation test in the MMC-OI relationship according to results in Model 3

		Mmc						
		0	10	20	30	40	50	60
Patents	0	3.42	12.38	17.43	18.55	15.76	9.05	-1.58
	400	3.28	12.90	18.61	20.40	18.27	12.22	2.25
	800	3.14	13.43	19.80	22.25	20.78	15.39	6.08
	1200	3.01	13.95	20.98	24.09	23.28	18.56	9.91
	1600	2.87	14.48	22.17	25.94	25.79	21.72	13.74
	2000	2.74	15.00	23.35	27.79	28.30	24.89	17.57
	2400	2.60	17.29	24.54	29.63	30.81	28.06	21.40

Discussion

The purpose of this study is to highlight new challenges in Open Innovation through the application of Multimarket Competition theory. This paper examines how firm innovation strategy can be shapes by the application of MMC mechanisms.

First, we analyse the impact of MMC mechanisms on the development of OI exchanges. We have argued that MMC intensive firms would present high rates of technological exchanges due to collusion arrangements and competitive structure implications. Results confirm this positive association. However, going into this relationship in depth, we looked for the possibility of the existence of quadratic effects. We understand that there are tipping points after which MMC can negatively affect the development of technological exchanges. Those firms with higher levels of market contact could face markets with high rates of potential competitors, so lower profitability expectations from collaboration. Moreover valuable technology creation would be constrained due to insignificant market differentiation across firms. Finally, resource allocation problems would emerge reducing the number of market object of technological exchanges. Our statistical analysis supports the existence of a U-inverted influence of MMC on OI exchanges.

Second, to build a reliable model we explore the insights of innovation literature in order to look for moderators in MMC-OI relationship. Literature posits active licensing activity as core assumption in the OI model. Firms with high patents stock would develop absorptive capacity, would improve their bargaining power in technological exchanges negotiations and would create an interaction pattern encouraging firms to develop more technological exchanges. Our empirical model confirms stock of patents as positive moderator in the MMC-OI association.

Several implications for managers arise from this research. Nowadays markets face the effects of an open environment, it does not make sense to remain close into traditional protection mechanisms. Managers should turn the traditional vision of competition into a chance for cooperation. The formula for being successful is linked to firm's adaptation capacity to new collaboration challenges. Our results point out the capacity of firms to innovate through the development of MMC. The chance of matching different firms across different markets would generate a powerful innovation pattern through collaboration.

The capacity to create a robust innovation strategy is the core goal for managers which leader high-tech firms. Managers which perform their activity in a technological sector must be aware of potential innovation sources to remain productive.

The application of MMC would support the development of technological exchanges. The creation of MMC depends on manager's ability to enter in new markets. Managers should invest in market penetration studies in order to look for markets sources of technological exchanges. At this point, managers should encourage diversification strategy to develop MMC. However managers should be aware of choosing a feasible number of markets which allow firm to develop a valuable technological exchange.

An additional implication arises when considering our results in the light of the creation of firm's stock of patents. Our research stresses the stock of knowledge implications on MMC-OI relationship. The efficiency of MMC on OI exchanges would be constrained to firm's level stock of patents. Managers which want to create an innovation pattern through MMC development should support an active licensing activity in order to have more robust results.

The novelty of this study implies a huge unexplored extension for multimarket and open innovation research. The conciliation of both schemes can be source of multiple studies in different management fields.

A limitation of the framework proposed is that it does not allow for the innovation complexity analysis. It would be interesting to focus on how technological exchanges developed through MMC would be source of incremental or radical innovation. This study could yield a new understanding of the efficiency of these technological exchanges.

Another future research challenge is related to the market analysis. In the present study we examine the MMC-OI relationship across different markets. However, we did not investigate the impact of MMC on technological exchanges according to the distinction between related and unrelated markets.

Finally, an additional implication arises when considering our results according to performance implications. We urge researchers to study MMC-OI relationship implications on firm's productivity. It would be necessary to translate the MMC capacity to create technological exchanges into economic efficiency.

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CHAPTER II

Building Product Diversification Strategy through R&D Contractual Agreements

ABSTRACT

In this article we focus on how R&D contractual agreements impact on product diversification strategy. We built on Open Innovation business models to understand Product Diversification strategy. This study examines how the development of different R&D contractual agreements (strategic alliances and licensing-in agreements) can be source of product diversification. We go further in this exploration through the study of current knowledge portfolio configuration as key mediator. Our hypotheses are tested through an original panel dataset for 102 Fortune high-tech companies from 8 different industries from 1999 to 2005. We find that strategic alliances have a positive impact on product diversification. We also offer empirical evidence for the role of firm´ s knowledge integration as a positive mediator between alliances and market penetration. On the other hand, knowledge integration acts as negative moderator when we consider the use of licensing-in agreements in product diversification.

Keywords: Open Innovation; Product Diversification; R&D Contractual Agreements; Knowledge Decomposability.

Building Product Diversification Strategy through R&D Contractual Agreements

Introduction

Diversification has been a traditional research field due to its broad perspective. Firms diversify into new business when they have excess capacities, or complementary assets, that can be reinvested in other business (Penrose, 1959). Literature in market diversification has been linked to resource-based view theory. The nature of organizational internal resources is presented as major driver to develop a diversification strategy (Penrose, 1959; Wernerfelt, 1984; Barney, 1986; Patel & Pavitt, 1997). Researchers have tried to explain the direction of diversification according to the nature of organizational knowledge, for which concept such as "relatedness" has been specifically defined. From this perspective, entry in a new business is not a random walk; the selection of markets for potential product introduction is going to depend on the nature of firm's innovation sources portfolio (core factor). Another body of diversification literature has focused on the relationship between knowledge relatedness and subsequent technological diversification in high-tech environments (Kim & Kogut, 1996; Piscitello, 2000). However, this literature does not explore the final impact on product diversification.

We acknowledge that to accomplish high-tech market necessities, firms must balance its capacity to develop know-how and their ability to diversify into new markets through the introduction of new products. Firms involve in schumpeterian competition, must adapt to rapidly evolving industries, where competitive capabilities are transitory, and opportunities are quickly closed by competitors (Kim & Kogut, 1996). Innovations in such environments quickly erode and firm must be aware to obtain relevant knowledge in order to develop efficient innovations to explore new markets.

No studies have so far viewed how the acquisition of external knowledge would impact on product diversification. In particular, no paper has studied the effect of R&D contractual agreements in firm’s capacity to penetrate into new markets. The role of R&D technological exchanges in innovation activity has been deeply explored by Open Innovation (OI) business models. OI explores the capacity of incumbents to collaborate each other through technological exchanges based on active contractual activity (Chesbrough, 2003).

We contribute to the literature on organizational innovation and diversification by showing how different external knowledge sources impact on market diversification strategy. Building upon Open Innovation literature, this article is a first attempt to analize the relationship between R&D contractual agreements and firm’s capacity to develop product diversification. We acknowledge that R&D contractual agreements run a large gamut of technological agreements characterized by different knowledge nature and subsequent search strategy. Therefore, we distinguish between strategic alliances and licensing-in agreements to understand its final impact of in product diversification. Distinction between external sources supposes a novelty in innovation search theory traditionally focused in internal and external knowledge sources differentiation.

The relationship between R&D contractual agreements and market diversification raises the question as to how current internal knowledge mediates on it. We contribute to theory of organizational knowledge structure to see how far firm’s current knowledge integration determines organizational ability to apply external knowledge in new product introduction.

To our knowledge, however, no previous work has tried to examine knowledge structural characteristics in product diversification settings. Specially, we define current knowledge structural configuration as key mediator in the relationship between R&D contractual agreements (strategic alliances and licensing-in agreements) and product introduction. Current knowledge structure will determine firm's ability to learn from new knowledge obtained trough different contractual agreements. Organizational ability to develop learning skills will condition product diversification strategy.

Our aim to reconcile Open Innovation and product diversification paradigms; lead to challenge previous empirical diversification research. We propose to test the model in the largest multinational companies, according to a product-niche analysis. We have built a novel panel dataset with a significant longitudinal dimension, using a sample of 102 Fortune high-tech firms from 1999 to 2005.

The paper is organized as follows. In the next section we present a literature review of Product diversification and OI (Open Innovation) framework. Then, we develop the critical questions of our study; we explore the effects of R&D contractual agreements in product diversification strategy. After developing the research questions, we describe the sample and the measures we use in the analysis. Finally the last two sections present the results and the conclusion of the study.

Theoretical Background

The paper builds and extends on three main lines of theoretical research. First, we use open innovation literature to analyse the characteristics of R&D contractual arrangements. Second, we focus on diversification theory to understand firm's motivations to penetrate into new markets. Third, we build on organizational knowledge structure theory to understand the implications of the current stock of knowledge in market diversification.

Recently, Open Innovation Business Model emerges as a new model developed by Chesbrough (2003). According to OI framework, high tech firms develop collaborative strategies in order to obtain higher performance rates and develop the most efficient technology. Open

Innovation explores the capacity of firms to collaborate each other through technological agreements, letting ideas both flow in and out of the corporation (Chesbrough, 2003). Technological exchanges are based on a dynamic in/out contractual activity. Open Innovation paradigm, balances in the same way the internal firm capacity and the external market players ability, in order to develop a stronger competitive position based on the exploitation of internal and outside competitor's knowledge which cannot be developed inside the company.

The combination of internal and external ability to innovate, suppose a challenge respect to traditional theories such as Absorptive Capacity Theory. Absorptive Capacity focuses on the role of internal firm capacity to create knowledge, and highlights the capacity of the firm to identify and assimilate external knowledge (Cohen & Levintahl, 1990). The creation of sustainable competitive advantage in Absorptive Capacity Theory relies on the internal firm capacity to absorb external knowledge, and the successful adaptation inside the firm. Absorptive Capacity Theory explores the internal sources as enactors of value creation, through the internal firm ability to exploit internal valuable resources, or through the internal ability to assimilate external knowledge.

On the other hand, OI presents R&D contractual agreements as the major driver of the model. The development of technological agreements among different market players would imply the penetration in new markets. The application of R&D contractual agreements generates information spillovers, which allow firms penetration into different markets due to improvement of organization learning ability to exploit external knowledge. Thus, diversification would be the logical consequence of technological agreements in Open business models. This allows us to perceive an important gap in previous research looking for R&D contractual agreements implications in the organizational innovation capacity.

Market diversification measures the extent to which a firm's activities are dispersed across different industries and the dispersion of activities across business segments within industries (Vachiani, 1991). Firms diversify into new business when they have excess capacities, or complementary assets, that can be reinvested in other business (Penrose, 1959). Diversification literature has been traditionally focused on resource-based view theory to explain firm diversification decision. The nature of organizational internal resources is presented as major driver to develop a diversification strategy (Penrose, 1959; Wernerfelt, 1984; Barney, 1986; Patel & Pavitt, 1997). Product diversification theory allows distinguishing between different diversification strategies according to the relatedness of markets object of penetration and technological diversification (Gambardella & Torrisi, 1998). The resource relatedness is considered as a concept exclusively associated with the inherent properties of the sectors (Piscitello, 2000). The degree to which a firm's businesses develop diversification strategy turns on the nature of the core factor they share and also on the idiosyncrasy degree between the factor and businesses using it (Williamson 1979; Rumelt, 1982). From this perspective, entry in a new business is not a random walk; the selection of markets for potential product introduction is going to depend on the nature of firm’s innovation sources (core factor).

However, research on diversification have implicitly or explicitly assumed that any resource valuable, rare, and inimitable enough to generate sustainable rents is too asset specific to be contracted out (Silverman, 1999). According to the previous consideration we can guess that firm diversify when there is not opportunity to sell its technology.

The third body of literature relevant to our study concerns the theory of organizational knowledge structure. Over time, literature studies in depth the implications in innovative productivity through knowledge stock characteristics (Fleming, 2001; Ahuja & Katila, 2001) or knowledge diversification (Laursen, Leone & Torrisi, 2008) to explain search process. Traditionally, organizational knowledge has been represented as sets of elements or individual pieces. However, new trends in organizational knowledge literature stress the role of structural configuration.

The structure of organizational knowledge base can determine how well a firm manages exploration and exploitation balance. If a firm's knowledge base is viewed as a network, a coupling can be seen as a tie or relationship between two knowledge elements. Couplings thus reflect an organization's revealed beliefs about which elements of knowledge are most likely to work well together and should be combined and, conversely, what kind of elements are unrelated to each other and do not need to be considered jointly (Ahuja &Yayavaram, 2008).

According to the different intensity among knowledge elements, we can distinguish between integrated and decomposable knowledge firms. This structural characteristic would help us to analyse the impact of technology acquisition in firm's market diversification strategy.

Hypotheses

Our theoretical framework will generate two hypotheses. Our goal is to explore the effect of different R&D contractual agreements on firm's product diversification strategies. The first hypothesis links the extent of firm's R&D contractual agreements on product diversification strategy. The second hypothesis analyses the role of the structure of firm's current knowledge portfolio as key mediator to explore R&D contractual agreements impact on product diversification strategies.

Literature of strategic management of innovation distinguishes between scope of search innovation strategies, exploitation and exploration. Exploitation aims at refinement and extension of existing competencies, technologies and paradigms, while exploration refers more specifically to learning or acquiring new knowledge and therefore innovation (March, 1991). Through exploration organizations can regenerate their existing knowledge and develop new capabilities to develop radical innovations (March, 1991; Gavetti & Levinthal, 2000; Nelson & Winter, 1982; Galunic & Rjordan, 1998; Fleming & Sorenson, 2001; Nerkar & Roberts, 2004;

Miller, Fern, & Cardinal, 2007). In order to take a knowledge access decision, firms must balance costs and risks of both choices (Katila & Ahuja, 2002).

Economic and managerial literature has presented the traditional search of innovation sources conflict as the “make or buy dilemma” (Veugelers & Cassiman, 1999). Open innovation paradigm implies development of technological transactions among market players using R&D contractual arrangements. Specially, we want to focus on how outsourcing innovation sources will impact on firm’s market diversification capabilities.

First of all, we have to understand the impact of R&D in firm’s innovation sources. As long as we study high-tech environments, cooperative R&D agreements allow firms to overcome resource constraints through learning skills and capabilities from other participants (Sakakibara, 1997). R&D contractual agreements are considered as an important way of explorative innovation in the literature (Koza & Lewin, 2000; Lavie & Rosenkopf, 2006).

Explorative innovation sources allow firm access to new knowledge different from firm’s original technological base, and enlarge its breadth of knowledge. The capability to upgrade products and diversify technology into related segments is often built on the accumulation of experiential know-how that allows for expansion during windows of opportunity (Kim & Kogut, 1996). The important role of firm’s innovation sources is its applicability to a wide set of market opportunities, this organizational capability is defined as technological platforms (Kim & Kogut, 1996). Kogut and Zander pointed out “what makes a technology a platform is its formative influence on a newly evolving trajectory that is characterized by increasing returns to investment in further exploration”.

Thus, organization technological stock resultant from R&D contractual agreements, will act as technological platforms. It will support further exploration due to network externalities from outside technology and accumulation of learning by doing that is useful for the generation of new products. The explorative direction of the technological capability will be linked to the diversification path of the firm into new markets (Kim & Kogut, 1996). As noted earlier, entry in a new business is not a random walk; is the outcome of firm's stock of knowledge.

Second, we point out the impact of innovation sources on product diversification. Knowledge transfer involves not only involves the acquisition of technology, but also information transfer about reputation and market conditions. We need to realize about the effects of R&D contractual agreements on the sourcing of information-intensive inputs.

Contractual agreements are considered as source of information spillovers due to extensive interactions and information exchanges among firms (Arora & Merges, 2004). Specially, R&D contractual agreements support explorative innovation strategy characterized by the acquisition of new knowledge.

Due to lack of experience in the new technological market, firms will be focused on overcoming experiential learning disadvantages. Therefore, the transfer of knowledge will be accomplish by information spillovers related to transfer experiential know-how about the unknown market such as innovation process, market characteristics, and product applications. The development of learning skills through information spillovers will encourage firms to exploit them by product introduction in previous unavailable markets. R&D contractual arrangements would have a positive impact on firm's product diversification strategy through the development of explorative learning skills.

Hypothesis 1: "The higher the number of R&D contractual agreements developed by a firm, the stronger will be the tendency of the firm to develop product diversification strategy"

The decision to penetrate into new markets is not a decision influenced only by company's capacity of acquiring external technology. Firms diversify in response to excess capacity in resources firm has purchased in the market, and special knowledge the firm has accumulated through time. Firms market trajectory is consequence of the combination of external knowledge and firm’s knowledge stock, firms will seek to improve and to diversify their technology by searching in zones that enable them to use and to build upon their existing technological base (Pavitt, 1988). In-house innovative sources allow firm to innovate following the path dictated by firm’s existing stock of knowledge, firm's level of breadth of diversification are a function of its resource stock (Montgomery, 1994).

It is necessary to analyse the structure of organizational knowledge base to understand the extent of the influence of firm’s technological stock on diversification strategy. A firm elects to enter into markets in which it can exploit its technological resources and in which its existing resource base is strongest (Patel & Pavitt, 1997; Pavitt, 1984; Markides & Williamson, 1994; Silverman, 1999).

Traditionally the relevance of knowledge stock has been linked to the relatedness between knowledge stock and the nature of the market object of entry. However, our point is to define the strength of technological stock as the organizational ability to combine different knowledge elements. The process of creating inventions is not simply a matter of recombining knowledge elements, because for even small knowledge bases, the large number of potential combinations of existing elements can lead to a combinatorial explosion of the number of possible inventions (Fleming & Sorenson, 2001).

The decomposability dimension of a knowledge base is important because it highlights that even organizations with knowledge bases consisting of the same elements of knowledge (and hence identical on the size and identity dimension) may still differ in their actual ability to use that knowledge because of variations in the decomposability of their knowledge bases. Thus an important implication of decomposability is that organizations can learn even without adding new elements to their knowledge bases (Ahuja & Yayavaram, 2008). As long as the extent of market penetration process is result of firm's capacity of product innovations, firm's level of integration of stock of knowledge will set the trend towards diversification strategy.

Organizational knowledge structures and its impact on firm's innovation can be classified according to the decomposability range from integrated levels (non-decomposable knowledge bases) through nearly decomposable knowledge bases to fully decomposable or modular structures. Extremely low levels of decomposability will limit search breadth and make effective recombination of any newly identified elements into successful inventions more complex and difficult. Moderate levels of decomposability should correct these deficiencies by allowing enhanced exploration and providing mechanisms to link the new knowledge discovered through broad search with the expertise born of specialization; they should also simplify the invention task, making effective combinations possible. But extremely high levels of decomposability, while introducing sufficient exploration, would provide no integration mechanisms to link the results of this exploration, limiting the likelihood of successful recombination and invention (Ahuja & Yayavaram, 2008).

Once we pointed out the implications of knowledge structure in the generation of inventions, we can define firm's market diversification strategy according to different levels of knowledge integration. High levels of knowledge integration will imply explorative moves across original knowledge configuration. Innovation will be constrained to current technological combinations, and firms will decide to stay in current markets or perform a specialization market strategy. On the other side low levels of knowledge integration (high decomposability levels) will support new configurations between different knowledge elements within certain cluster and across cluster boundaries. This large number of potential interconnections would encourage exploration and innovations based on new technological elements allowing firms to penetrate into new markets.

At noted earlier, market diversification strategy is consequence of combination of external and internal knowledge. The important point is to characterize the role R&D contractual agreements in diversification strategy according to organizational level of knowledge integration.

We distinguish between in-licensing and strategic alliances contractual agreements and its implications in product introduction according to search breadth, deep knowledge and integrative mechanisms.

Alliances have been traditionally considered as an efficient mechanism to acquire technological capabilities from partners. Specially, these agreements engage interfirm collaboration to gain access to other firms' capabilities supporting intensive exploitation of existing capabilities within each firm. Strategic alliances involve more complex contractually based arrangements than licensing contracts, such as technology sharing and joint development agreements which often include joint ownership or other organizational mechanisms for oversight and management (Mowery, Oxley & Silverman, 1996). Alliances stress the capacity of the firm of accessing rather than acquiring external capabilities for the creation of internal innovation. Knowledge transfer success depends on firm’s capacity to learn from alliance partner through knowledge internalization (Hamel, 1991; Mowery, Oxley & Silverman, 1996).

Strategic alliances are considered as cooperative R&D agreements which key objective is complementary knowledge among participants (Sakakibara, 1997). The knowledge obtained through alliances is going to be complementary to firm’s knowledge base (Mowery, Oxley & Silverman, 1996), it is going to allow organizational embeddedness of new technology and the development of integrative coordination mechanisms will be easier due to knowledge coherence. Coherence is the result of a trial-and-error process, and what may be related diversification and coherent organization for one firm, may not be so for another firm. The firm becomes an experimental device for selection: by exploring new combinations of capabilities, the firm incrementally and cumulatively learns which capabilities are related, and collects these together within its organization as a coherent whole (Cantwell, 1998).

From previous discussion, firms with high levels of knowledge integration find difficult to adopt changes in knowledge elements and tend to resist to exploratory search, due to large number of interdependencies among elements. Combined, all this shows that knowledge obtained through strategic alliances will fit to original constraints imposed by firms with high levels of organizational knowledge integration.

Due to the existence of strong couplings, which work as integrative mechanisms, the adoption of new knowledge is going to impact on different clusters. The introduction of a new element through alliances, expand cluster boundaries through "adaptive walks", these movements across clusters are going to encourage firm to move from original configuration and lead to improvements in broader search and support exploration. Accordingly, a coherent final stock of knowledge and the development of "adaptive walks," will support the emergence of organizational technological platform capability with a clear explorative trajectory (Kim & Kogut, 1996).

Once we pointed out the impact of strategic alliances agreements in firm's innovation search strategy, we analyze subsequently the final effect on product diversification strategy. As discussed before, R&D contractual agreements involve not only technological access, but also information exchange. High knowledge integrated firms will benefit from strategic alliances through exploitation of information spillovers.

In a first stage, alliances in knowledge-integrated firms involve explorative search strategy by the acquisition of external technology. The access to information about unknown technological market would overcome experiential learning disadvantages to exploit this new technology. Specially, firms with high levels of knowledge integration will support external skills internalization through the existence of integration mechanisms. External market information embeddedness will allow firms to exploit its learning skills in new product introductions, the capacity of the organization to internalize partner's skills increase firm's ability to apply them into new markets, new products and new businesses (Hamel, 1991). Therefore, the successful exploitation of external knowledge through integration mechanisms will reach an optimal level through information spillovers and subsequently learning skills internalization.

This combination will allow firms to develop new products based on larger number of potential interconnections and technological combinations, encouraging firms to perform market diversification strategy. This leads us to conjecture:

Hypotheses 2a: "Firm's knowledge integration work as positive moderator between strategic alliances and product diversification strategy"

On the other side, in-licensing represents a form of contractual arrangement, which is closed to pure market transaction (Arora, Fosfuri & Gambardella, 2001). Firms benefit from external market players ability, in order to develop stronger innovation capabilities based on the exploitation of outside knowledge, which cannot be developed inside the company. Licensing should allow gaining acquiring knowledge that is distant from the firm's technological background (Laursen et al.2008).

As long as high integrated knowledge firms do not accept changes in current knowledge structures, exploratory knowledge will not be embedded. Organizational coherence will not emerge due to lack of related technological capabilities. Integrative mechanisms will not work due to interdependencies constraints, when inventors consider the any change in one knowledge element they take into account the effect of this change in other related elements (Ahuja &

Yayavaram, 2008). As long as the knowledge acquired by licensing is not familiar, the threshold to accept the new configuration would by higher.

Considering both, integrated knowledge firms and in-licensing follow the argument that exploration and exploitation are complements in the long run but likely to be substitutes at a given point in time, as synchronically substitutes (Laursen et al. 2008).

This idea is in line with the not-invented here (NIH) syndrome in which firms resist accepting innovative ideas from the environment because outside ideas may be too distant from the firm's existing knowledge base to be either appreciated or accessed (Cohen & Levinthal, 1990). As consequence of NIH syndrome, firms would encourage innovation trough exploitation of current knowledge sources. Due to firms with high level of knowledge integration deter explorative search, organization will not achieve technological platforms.

Accordingly, we must explore how exploitation of current sources will impact on product diversification strategy. Exploitative innovation search strategy based on firm’s current sources will deter the acquisition of new external knowledge.

Firms will not benefit from new information spillovers in order to develop learning skills in unavailable markets. However, exploitation search strategy will support current integration mechanisms characterized by strong couplings. Therefore, organization will reinforce its experiential learning advantages in current markets leading to product specialization. Development of licensing-in agreements by knowledge-integrated firms generates a lack of consistency in innovation strategy, which encourages market specialization strategy by exploitation of current integration mechanisms and exploitative learning skills.

Hypotheses 2b: “Firm’s knowledge integration works as negative moderator between in-licensing contractual agreements and product diversification strategy”

Methods

Data and Sample

Our sample is composed by large companies because they operate in operate in different markets of products with several overlaps. A second selection criterion is focusing on high tech sectors in which alliances and licensing agreements are usual mechanisms across firms to acquire external technology.

We identify large companies through Fortune Global 500 2006. Fortune Global 500 2006, present the list of largest world companies classified into 52 sectors. Among these 52 sectors, we identify high tech sectors through Compustat database, looking for R&D overall sector expenses. The sectors selected are the following: aerospace and defense, chemicals, computer & office equipments, electronics & electrical equipment, motor & vehicle parts, pharmaceutical, semiconductors and telecommunications. The sample generates 714 observations on 102 companies classified into 8 different industries from 1999 to 2005.

Measures

Dependent variable

Product introduction variable is related to the diversification capacity of the firm to penetrate in a new market niche from 1999 to 2005. Product introduction occurs when a firm *i*, an incumbent in a focal market *m* (a certain SIC code) penetrate in another market *n* (a different SIC code from the previous one).

We obtain the data through Info Trac Database. We search for all articles that reported the name of the company and the word "product introduction". We extract the name of the company, the date of product introduction and the line of business of product introduction (four digits SIC code). After this initial classification we rely on categorical decision rules to compute product introduction according to the diversification degree. As long as product introduction variable is time dependent, we codify each observation according to the proximity of the market SIC code four digits from the current year to previous ones. If a firm does not introduce any product in year t, that is codified as product introduction=0. We codify product introduction=1 when firm penetrate in same 4-digit market than previous years). On the same way, we consider product introduction=2 when firm penetrate in same 3-digit market, product introduction=3 if in same 2-digit market, product introduction=4 if in same 1-digit market and product introduction=5 if in total 4 digit different SIC codes.

Independent Variables

Open Innovation variable is related to the number of technological contractual agreements among firms from 1999 to 2005. We extract this data from InfoTrac Database.

R&D contractual agreements variable is related to the number of technological agreements among firms from 1999 to 2005. In order to look for technological agreements, we search for all articles that reported the name of the company (Fortune R&D companies) and "licensing-in agreements" and "strategic alliances" from 1999 to 2005. After this initial classification, we read all the articles in order to filter technological contracts to obtain the number of R&D technological licenses and R&D strategic alliances, excluding for example marketing agreements. Then, from each of these articles we extract the date of technological agreement, the name of the companies involved.

R&D contractual agreements measure the number of firm's technological agreements (sum of strategic alliances and licensing agreements over time).

$$\sum_{j \neq 1} \text{R\&D Contractual Agreements}_{ijt} = \sum_{j \neq 1} \text{Strategic Alliances}_{ijt} + \sum_{j \neq 1} \text{Licensing Agreements}_{ijt}$$

The second variable reflects firm's stock of knowledge level of integration. Here we follow earlier studies, which have relied on coupling indicators as measure of knowledge integration (Ahuja & Yayavaram, 2008).

A firm's knowledge base or patent portfolio at t is assumed to consist of all the patents that the firm has accumulated during t – 3 to t –1 year. To ease calculations, we assumed that the technology classes assigned to patents are the elements in the firm's knowledge base (Fleming and Sorenson, 2001).

We extract this data from NBER for the firm's object of study. Due to NBER considers only one technological class per patent; we look for backward patent cited to find the background technological class for each firm's patent. We ranked the classes by the number of firms that had patents assigned to that class and then considered the top 30 to be in our 102 cross-industry firms.

We use Jaccard's coefficient ratio to compute he knowledge coupling between technology classes j and k for firm i, (Ahuja & Yayavaram, 2008).

$$L_{i,j\text{-}k,t\text{-}3\ to\ t\text{-}1} = a / (a + b + c)$$

where a is the number of patents that are assigned to both classes, b is the number of patents assigned to class i, but not class j, and c is the number of patents assigned to class j, but not class i. The coupling matrix, L i, j-k, t-3 to t-1 consisting of L i, j-k, t-3 to t-1 for all pairs of elements, represents the structure of the firm's knowledge base.

To obtain the final measure of knowledge integration we compute the average of the jaccard coefficient taking into account all pair of elements of each firm each year. Low levels of knowledge integration, imply high decomposability in knowledge structure with few numbers of interdependencies among knowledge elements. However, high integration values, reveals large number of couplings and strong interdependencies in the knowledge structure.

Control Variables

In addition to the variables proposed to test the hypothesis, we also control for other factors suggested by diversification and open innovation literature.

Patent stock controls for firm’s level of protection against competitors. We extract the information through the United States Patent and Trademark Office (USPTO). We report the total number of patents of each firm from 1999 to 2005.

One of the main challenges of this study is the understanding of R&D agreements in market diversification strategy according to firm’s level of knowledge integration. Traditionally stock of knowledge has been analyzed from its diversification perspective. In order to differentiate the role of stock knowledge structure from stock knowledge diversification, we include Herfindhal index as control variable in our model. This index reflects the degree of dispersion of the firm’s patents across different NBER technological classes. The index varies between 0 and 1. The final index variable for each firm each year is computed as the average of firm’s Herfindhal indexes each period. The lowest the index, the broader the scope of the licensee’s technological expertise and therefore, the more likely it will be able to enter new technologies. Firms with a dispersed patent portfolio have learned to manage different technologies and therefore should display a greater ability to enter into a new technological field compared with firms endowed with a narrow technological portfolio (Laursen et al.2008).

Finally, we include three groups of dummy variables: nationality, the sector, and the year object of study. We have to control the nationality of the firm in order to realize about the influence of the firm’s origin on the results.

We define 12 dummy variables according to our firm's nationality (USA, UK, Canada, France, Japan, South-Korea, Netherlands, Germany, Sweden, Italy, Switzerland, and Spain). The second group of dummy variables controls for the sector characteristics to avoid the impact of industrial innovation capacity on the regression. We obtain 8 sector dummy variables according to the Fortune high tech sector's classification (aerospace and defense, chemicals, computer & office equipments, electronics & electrical equipment, motor & vehicle parts, pharmaceutical, semiconductors and telecommunications). Moreover we need to control for the year object of study to avoid the influence of macroeconomic trends such as economic cycles and periods of technological ferment that could affect technological agreements. Due to our analysis study run the gamut from 1999 to 2005, we have 7-year dummy variables.

Table 1 reports the descriptive statistics for our analysis. If we look at our core variables values in Table 1 we can see that on average, a firm performs 2,32 alliances by year, with a maximum value of 36 and a minimum value of 0.

Looking at licensing in, firms develop on average 1,48 agreements, with a maximum value of 16 and 0 as the minimum. If we look at our integration measure, the mean is 0,014, with the upper value equal to 0,214 and the lower value equal to 0. As shown in Table 1, product introduction variable, takes on average a value of 1,33; the minimum value, which implies no product introduction is 0, and the maximum value is 5 meaning that a firm penetrates into extreme unrelated market.

Table 1. Descriptive statistics and Correlation Matrix

Variable	Obs	Mean	Std. Dev.	Min	Max	Product Introduction	Strategic Alliances	Licensing-in	Patents	Knowledge Integration	Herfindhal Index
Product Introduction	525	1.41	1.64	0	5	1.00					
Strategic Alliances	525	2.73	4.61	0	36	0.32	1.00				
Licensing-in	525	1.69	2.70	0	16	0.17	0.67	1.00			
Patents	525	320.43	505.98	0	2312	0.12	0.32	0.31	1.00		
Knowledge Integration	525	0.02	0.03	0	0	-0.03	-0.16	-0.19	-0.20	1.00	
Herfindhal Index	208	0.01	0.08	0	1	0.06	-0.05	0.03	-0.15	-0.01	1.00

Results

As our dependent variable is categorical we use ordered probit model. Table 2 reports the analysis of R&D contractual agreements impact on diversification strategy. Model 0 supports Hypothesis 1 for strategic alliances, as long as the number of strategic alliances would be higher, firms would diversify more in new markets. On the other hand, we find a negative impact of licensing-in agreements in market diversification, however it is not statistically significant.

Model 1 focuses on the effect of knowledge integration in product diversification capacity. We find support for the positive impact of knowledge integration in the dependent variable. Moreover we find interestingly that alliances remain positively significant with the introduction of the new variable.

In model 2, we introduce interactions between R&D contractual agreements and knowledge integration. The interaction of strategic alliances and knowledge integration is positive and significant in the test. On the other hand, we find a negative significant effect in licensing-in agreements and knowledge integration interaction. These results support Hypotheses 2a and Hypotheses 2b. When firm's stock of knowledge is integrated, strategic alliances encourages market diversification strategy. However, in presence of firms with integrated knowledge, licensing-in agreements deter market diversification. In this new model, we also find support for Hypotheses 1, alliances remain positively significant in the development of market diversification strategy.

Finally in Model 3, we control for firm's diversification stock of knowledge through the introduction of Herfindhal index. We find that this variable is not significant in developing market diversification strategy. With the inclusion of this new control, the core variables (alliances, alliances*integration, licensing-in*integration) remain significant. Dummy variables (sector, year and nationality) are consistently positive and significant in explaining the relationship between R&D contractual agreements and product diversification strategy.

Table 2. Determinants of Product Diversification. Results of Order Probit Regressions.

Independent Variables	Model 0	Model 1	Model 2	Model 3
Strategic Alliances	0.05***	0.05***	0.04**	0.06**
	(0.02)	(0.02)	(0.02)	(0.03)
Licensing-in	-0.01	-0.01	0.01	0.05
	(0.02)	(0.03)	(0.03)	(0.04)
Patents	0.00***	0.00***	0.00***	0.00
	(0.00)	(0.00)	(0.00)	(0.00)
Knowledge Integration	-	3.64*	2.9	-9.65
		(1.96)	(2.69)	(7.13)
Strategic Alliances* Knowledge Integration	-	-	1.70*	7.59***
			(1)	(2.25)
Licensing-in*Knowledge Integration	-	-	-1.83*	-3.31**
			(1)	(1.60)
Herfindhal Index	-	-	-	1.56
				(1.20)
Dummy Sector		Yes		
Dummy Nationality		Yes		
Dummy year		Yes		
Number of obs	525	525	525	208
Wald chi2(26)	4290.2	3835.3	3663.21	116.01
Prob>chi2	0	0	0	0
Pseudo R2	0.2324	0.2348	0.2372	0.2833

One-tailed *t*-test applied. * $p < 0.10$; ** $p < 0.05$; *** $p < 0.01$

Due to the existence of missing values in the sample we have considered 75 firms in our models. However, to check results reliability, we apply a new probit model considering all 102 firms in the sample. We control for two new dummy variables related to integration and herfindhal index respectively. This new analysis confirms our results, main variables remain significant and there is not statistical difference from the previous model.

In order to go deeper on the analysis of the OI- Market diversification relationship we perform a simulation test to predict the behavior of our variables.

We analyze the value of Product introduction dependent variable according to the value modification of the core variables (strategic alliances, licensing in-in agreements and integration coefficient) and stock of patents. We set the variables at (mean-std.deviation; mean+std.deviation). Then we rely in our final probit model to perform a prediction. In this way, we obtain two tables according to modification of value core variables.

The first table predicts the average of Product introduction according to modification of strategic alliances and integration variables. We find that higher values of product introduction (0.94) are associated to higher values of alliances and knowledge integration as posited in our second hypotheses. However, high values of alliances and low levels of integration deter firm’s capability to introduce new products (-2.13).

On the other hand, second table refers to product introduction average taking into account licensing-in and integration variables modification. The highest value of product introduction is related to high levels of licensing-in agreements and low knowledge integration (-0.23). Lower levels of licensing-in agreements and lower values of knowledge integration reach the lowest value of product introduction.

Table 3. Simulation Test in the R&D Contractual Agreements- Product diversification Relationship

		INTEGRATION	
		INTEGRATION I	INTEGRATION II
ALLIANCES	ALLIANCES I	-0.57 (0.60)	-2.13 (0.77)
	ALLIANCES II	-0.77 (0.63)	0.94 (0.73)

* I= (variable mean – variable std.deviation)

** II= (variable mean + variable std.deviation)

*** Prediction Standard Errors reported between parentheses

		INTEGRATION	
		INTEGRATION I	INTEGRATION II
LICENSING-IN	LICENSING-IN I	-0.84 (0.63)	-0.36 (0.60)
	LICENSING-IN II	-0.27 (0.73)	-0.77 (0.65)

* I= (variable mean – variable std.deviation)

** II= (variable mean + variable std.deviation)

*** Prediction Standard Errors reported between parentheses

We perform a robustness test by the application of a Hazard model to obtain a reliable relationship between product diversification and R&D contractual agreements. A piecewise-constant model is an exponential hazard rate model where the constant rate is allowed to vary within pre-defined time-segments. We define all time segments from 1999 to 2005. The Hazard model application verifies previous ordered probit results. First, the development of strategic alliances has a positive influence on the probability of the firm to introduce new products. Second, knowledge integration and R&D agreements interactions remain constant. Strategic alliances have a positive influence on product diversification in firms with high knowledge integration. However, licensing-in has a negative influence on firm's product diversification strategy in high knowledge integrated firms.

Discussion

This paper started by observing that literature in product diversification has been mainly focused on the knowledge relatedness between existing knowledge portfolio and nature of market object of diversification. Research has not explored the effect of the acquisition of new knowledge in market diversification strategy. Our purpose is to understand the impact of R&D contractual agreements in organizational decision to diversify into new markets.

First, we analyze a positive direct relationship between R&D contractual agreements and product diversification strategy. In the empirical test we find that strategic alliances confirm our hypotheses, however licensing-in agreements are not significant and coefficient variable is negative. Our explanation is that motivation for alliances and licensing-in is different according to knowledge characteristics and different implications in current technological portfolio. We can guess the existence of a latent mediator in its relationship with Product introduction variable.

Table 4. Robustness test. Hazard Model Results.

Independent Variables	
Core Variables	
Strategic Alliances	1.04* (0.02)
Licensing-in	0.96 (0.04)
Patents	1.00 (0.00)
Knowledge Integration	0.00*** (0.00)
Strategic Alliances* Knowledge Integration	1395.62*** (3555.08)
Licensing-in* Knowledge Integration	347.41** (1044.22)
Herfindhal Index	282.69** (645.62)
Dummy Sector	Yes
Dummy Nationality	Yes
Dummy Year	Yes
No. of subjects	44.00
Number of obs	61.00
No. of failures	37.00
Time at risk	87973.00
Wald chi2(25)	1.93E+12
Log pseudolikelihood	-13.32
Prob > chi2	0.00

One-tailed *t*-test applied. * p < 0.10; ** p < 0.05;*** p <0.01

Second we look for a key mediator in our association. It is necessary to take into account the implications of existing organizational knowledge to understand the adoption of external knowledge on firm's product introduction capabilities. Organizational knowledge integration reflects the strength of knowledge structure and its effect on innovation creation. Knowledge integration will generate different implications in product diversification depending on organizational knowledge capabilities to deal with the adoption of external technology. Thus, we stated two hypotheses related to integration knowledge mediation in the association between R&D contractual agreements (strategic alliances and licensing-in, respectively) and product diversification strategy. The first hypothesis reveals that the adoption of strategic alliances in firms with high knowledge integration would encourage penetration into new markets. On the other side, the adoption of technology through in-licensing contracts in firms with high knowledge integration would encourage product specialization. Our statistical analysis confirms knowledge integration as significant mediator in R&D agreements and product diversification strategy (positive interaction with strategic alliances and negative mediation with licensing-in agreements).

This study deepens our understanding of sources of firm´s capacity to diversify into new markets. We analyze product diversification assumptions from a new perspective realizing about high-tech market conditions. In particular, our research builds a new diversification pattern taking into account R&D contractual agreements. We have defined a new role of traditional open innovation mechanisms in firm´s capacity to introduce new products. Furthermore, we explore the joint impact of technological agreements and current knowledge structure in product diversification. The novelty of this study implies a huge unexplored field to go deeper on technological contractual agreements and product diversification research. Future research could enlarge contractual agreements perspective. This would allow us to differentiate between the effect of R&D agreements and other contracts not related with technology acquisition in product introduction strategy. In line with previous argument, another limitation of the framework proposed is the unique consideration of strategic alliances and licensing-in agreements as R&D contractual agreements. It would be interesting to enlarge the R&D contractual agreements options and its diversification implications. The conciliation of both schemes can be source of multiple studies in different management fields. Several implications for managers arise from this research. First, managers in high-tech environments have to examine and evaluate the R&D contractual agreements alternatives to develop an efficient product diversification strategy. Managers must differentiate between strategic alliances or licensing-in agreements due to its different impact on product introduction. Second, managers who decide to diversify into new markets and develop R&D contractual agreements cannot obviate the organization's knowledge structure. It is necessary to analyze jointly the development of strategic alliances and licensing-in agreements and firm's level of knowledge integration to determine market diversification. Managers have to study knowledge integration in existing technological portfolio to develop product diversification strategy when firms use contractual agreements to access to external technology.

Besides contributing to product diversification theory we have challenged its empirical validation. Our novel sample is based on large multinational companies, which play in high innovative environments. We have built an original panel dataset for 102 Fortune high-tech companies from 8 different industries from 1999 to 2005. We acknowledge that, that interpreting the complex interactions among R&D contractual agreements, knowledge integration and product diversification is a very difficult task, future research could focus on further scrutiny, possibly based on in-depth case studies.

Nevertheless, we believe that this paper is an important first attempt at better understanding how R&D contractual activity helps firms to develop product diversification strategy.

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CHAPTER III

Upstream and Downstream Diversification: Opportunities and Threats in Innovative Productivity

ABSTRACT

In this article we focus on how both upstream and downstream diversification impact on organizational innovative productivity. We built on diversification theory to understand innovation strategy from two different scopes (product and knowledge productivity). This study examines the influence of business and technological diversification on firm’s ability to introduce new products and knowledge search productivity. Our hypotheses are tested through an original panel dataset for 99 Fortune high-tech companies from 8 different industries from 1999 to 2005. We find that upstream diversification discourages product introduction. On the other side, downstream diversification supports the adoption of new knowledge.

Keywords: Upstream Diversification; Downstream Diversification; Product Introduction; Knowledge Productivity

Upstream and Downstream Diversification: Opportunities and Threats in Innovative Productivity

Introduction

Are the innovative strategies of diversified firms more productive than those of specialized firms, and if so, why?

Organizations rely on innovative capacity as main source of competitive advantage. Literature understood organizational innovative productivity from two different perspectives: Product introduction and knowledge search productivity.

Research has traditionally distinguishes between these two scenarios by the application of different theories. Product innovation has been broadly studied through resource-based view theory which presents new product success as firm's capacity to create value from firm existing skills and resources (Daneels, 2002). Organizational ability to identify and combine different core capabilities will determine firm's ability to generate new products.

On the other hand knowledge search productivity has been studied according to different theoretical scopes. Over time, literature studies in depth the implications in innovative productivity through knowledge stock characteristics (Fleming, 2001; Ahuja & Katila, 2001; Laursen, Leone & Torrisi, 2008) to explain search breadth process. However, research has not provided a whole innovative productivity perspective for the joint analysis of product introduction and knowledge search productivity.

We acknowledge that to accomplish high-tech market necessities, firms must balance its capacity to combine different innovative sources and organizational know-how and their ability to develop technological and product innovations. Firms involve in schumpeterian competition, must adapt to rapidly evolving industries, where competitive capabilities are transitory, and opportunities are quickly closed by competitors (Kim & Kogut, 1996). Technological and product innovations in such environments quickly erode and firm must be aware to obtain and combine different resources from different landscapes in order to develop efficient innovations to generate competitive advantage over rivals. No studies have so far viewed how organization resources and business dispersion would impact on innovative productivity. In particular, no paper has studied the effect of organizational diversification in firm's product introduction ability and knowledge search productivity, respectively.

Diversification has been a traditional research field due to its broad perspective. Firms diversify into different landscapes when they have excess capacities, or complementary assets, that can be reinvested (Penrose, 1959). Literature in organizational diversification has been linked to resource-based view theory. The nature of internal resources is presented as major driver to develop a diversification strategy (Penrose, 1959; Wernerfelt, 1984; Barney, 1986; Patel & Pavitt, 1997). Researchers have tried to explain the direction of diversification according to the nature of organizational knowledge. From this perspective, diversification is not a random walk; the selection of different landscapes is going to depend on the nature of firm's innovation sources portfolio (core factor) and firm's ability to generate cost advantage through economies of scope.

We acknowledge that diversification can be classified as upstream or downstream diversification. Both scopes of diversification rely on different organizational sources (product and knowledge, respectively) and determine subsequent organizational ability to create synergies across firm's business or technological landscapes. Therefore, the study of upstream and downstream diversification will allow us to analyze a whole perspective of innovative strategy covering product and technological domains. Distinction between both diversification streams and innovative productivity scope supposes a novelty in innovation theory traditionally focused in isolated technological or product perspectives.

Our aim to reconcile diversification and organizational innovation paradigms, lead us to challenge previous empirical diversification research. We propose to test the model in the largest multinational companies according to business and technological diversification. We have built a novel panel dataset with a significant longitudinal dimension, using a sample of 99 Fortune high-tech firms from 1999 to 2005.

The paper is organized as follows. In the next section we present a literature review of diversification, product innovation and knowledge search framework. Then, we develop the critical questions of our study; we explore the effects of upstream and downstream diversification strategy in innovative productivity. After developing the research questions, we describe the sample and the measures we use in the analysis. Finally the last two sections present the results and the conclusion of the study.

Theoretical Background

The paper builds and extends on four main lines of theoretical research. First we use upstream diversification literature and product innovation theory to analyse the impact of organizational business scope on firm’s capacity to introduce new products. Second, we build on downstream diversification research and organizational knowledge theory to understand the implications of the current stock of knowledge structure in knowledge search productivity.

Upstream diversification measures the extent to which a firm's businesses are dispersed across different industries and the dispersion of activities across business segments within industries (Vachiani, 1991). Firms penetrate into new business when they have excess capacities, or complementary assets, that can be reinvested in other business (Penrose, 1959). Product diversification theory allows distinguishing between different business diversification strategies according to the relatedness of markets object of penetration and technological diversification (Gambardella & Torrisi, 1998). The resource relatedness is considered as a concept exclusively associated with the inherent properties of the sectors (Piscitello, 2000). The degree to which a firm develop market diversification strategy turns on the nature of the business core factor they share and also on the idiosyncrasy degree between the factor and businesses using it (Williamson 1979; Rumelt, 1982). Benefits from diversification involve utilization of excess resources within firm to achieve economies of scope. Economies of scope derive from sharing of intangible or tangible in the production of multiple products resulting in lower joint costs of production per unit of output (Helfat & Eisenhardt, 2004). From this perspective, entry in a new business is not a random walk; the selection of markets for potential product introduction is going to shape the nature of firm's innovation sources (core factor) and determine the organizational ability to create profitable synergies across different business units.

Literature has traditionally examined product innovation from a resource-base perspective. Research presents new product success as firm's capacity to create value from firm existing skills and resources (Daneels, 2002). However, product innovation is a dynamic process, which depends on different capabilities combination. Resource-based view considers the role of product innovation as dynamic capability due to its ability to alter the resource configuration of the firm by creating, integrating, and recombination of resources (Eisenhardt & Martin, 2000). Organizational experience and specialized complementary assets supported the success of incumbent firms in developing products based on different generations of technology (Tripsas, 1997). Organizational competence is used to refer to an ability to accomplish something by using a set of material and immaterial resources (Grant, 1991). The insight into the reciprocality of the product innovation competence relation extends resource theory by examining not only how competences are used in product innovation, but how they are built as well, and by examining how one competence can be used to build another (Daneels, 2002).

Therefore, traditional research focuses on organizational ability to innovate through optimal resource allocation. However in order to build a whole product innovation perspective we need to understand how firms’ capacity to realign product competences will influence on innovative productivity.

Downstream diversification measures the extent to which a firm's resources are dispersed across different technological landscapes. This stream of the literature has focused on technological and organizational determinants of diversification produced by economies of scope, cognitive boundaries, and organisational inertia (Rumelt, 1974, 1995; Panzar & Willig, 1981; Teece, 1988; Montgomery & Wernerfelt, 1988; Pavitt, 1991; Teece et al., 1994). These studies point to the importance of firm-specific excess resources subject of reuse in different technological domains and firm’s ability to create profitable networks to achieve cost advantage across organization’s technological landscapes. The importance of indivisible assets, specialized resources and learning by doing determine the dynamics of diversification (Helfat & Eisenhardt, 2004). The nature of these resources and the imperfections of their markets can give rise to increasing returns to diversification and productivity (Gambardella & Torrisi, 1998).

The last body of literature relevant to our study concerns the theory of knowledge recombination. Over time, literature studies in depth the implications in innovative productivity through knowledge stock characteristics (Fleming, 2001; Ahuja & Katila, 2001). Traditionally, organizational knowledge has been represented as sets of elements or individual pieces. However, new trends in organizational knowledge literature stress the role of knowledge configuration.

In order to understand the role of knowledge recombination, literature points out its implications in innovation strategy. Research considers invention as a new synthesis of existing and new technological components or a refinement of a previous combination of technologies (Fleming & Sorenson, 2001). Potential configurations of knowledge components represent different technological landscapes (Kauffman, 1993). Therefore, in order to build a reliable knowledge recombination, firm must assess if the change in one component is going to impact in different component landscapes. Fleming and Sorenson (2001) define interdependence as: “the functional sensitivity of an invention to changes in its constituent components”. Interdependence across knowledge elements determines the fruitfulness of knowledge search on different landscapes. The organization challenge is to obtain the best technological fitness according to technological recombination taking into account knowledge interdependencies (Nelson & Winter, 1982; Stuart & Podolny, 1996).

This structural characteristic helps us to analyse the organizational capacity to combine different knowledge resources and determine its final impact on firm’s knowledge search productivity.

Hypotheses

Our theoretical framework will generate two hypotheses. Our goal is to explore the effect of organization diversification on firm’s innovative productivity according to both product and technological perspective. The first hypothesis links the extent of firm’s upstream diversification on firm’s ability to introduce new products. The second hypotheses analyses the role of downstream diversification on firm’s knowledge productivity.

Literature of upstream diversification explores the role of diversification strategy to generate economies of scope (Gambardella & Torrisi, 1998). Research focuses on firm’s ability to share organizational resources among different business to reduce product costs (Penrose, 1959; Rumelt, 1974; Helfat & Eisenhardt, 2004). Therefore, getting cost advantage will be constrained to company’s ability to create market synergies according to the importance of indivisible assets, specialized resources and learning by doing.

However, in order to understand the process to obtain market synergies we need to explore product innovation characteristics in high- tech environments.

Product invention is considered either a new synthesis of existing and/or new technological components or a refinement of a previous combination of technologies (Fleming & Sorenson, 2000). Product innovation requires two key tasks, to physically make the new product and to sell this product to certain customer. As posited by Danneels (2000), technological competence reflects such technically related resources such as: design and engineering know-how, product and process design equipment, manufacturing facilities and know-how, and procedures for quality control. Market competence relies on such market related resources as: knowledge of customer needs, preferences, purchasing procedures, distribution and sales access to customers, and communication channels for exchange of information between the firm and customer during development and commercialisation of the product. Organizational experience allows firms to accomplish these competences through routines or procedures, which codify knowledge to cope quickly and effectively with its environment (Henderson, 1993).

The innovation in high-tech markets involves demand and technologies in flux, these fast-paced markets imply short product-life cycles and high asset specificity (Chandler, 1990). Firms which develop a profitable upstream diversification strategy will have to assembly different product specific innovation processes, firms' ability to generate technological and customer competences must be greater. However, not only creating isolated product-market competences, but also consistent with other product-markets.

As long as companies penetrate into new markets, nature of organizational resources will became more heterogeneous. Organizational procedures and information filters developed through experience will become partially obsolete. Therefore, product competences are not sufficient to enter into new markets, but complementary competences across different product-markets are the necessary condition for success. The capacity to create synergies between different product-markets will be determined by the cost of transferring resources among different business. Integrative capability refers to the ability of an organization to absorb new business and to manage a variety of different businesses on a continuing basis (Helfat & Eisenhardt, 2004). Product and asset specificity will have a negative impact in the creation of integrative capability. Organization will not be able to transfer technological and market competences among business due to the importance of: indivisible assets, such as research and development that supports certain product-market; specialized resources technological and marketing competences; and organizational inability to benefit from learning by doing due to asset specificity.

Organizational inability to generate integrative capability will lead to diseconomies of scope. Two kinds of negative returns will arise to diseconomies of scope attending to cost and spillovers disadvantages (Henderson & Cockburn, 1996). Firstly, joint production and market of different specific products will not lead to cost advantages when products require specialized facilities (Chandler, 1990). However, the total cost of producing different product-markets will increase due to firm's inability to generate integrative capability in diversified markets. Second, the emergence of internal spillovers of knowledge between different product-markets will harm each other market power due to product specificity and competences overlapping.

In order to understand the impact of diseconomies of scope in the innovative productivity of the firm we must explore the role of detrimental spillovers. Organizational willingness to innovate is constrained to firm's ability to maintain its current market power and its business dominant position (Chandy & Tellis, 1998; Henderson, 1993). As we have posited before, diversified firms involve specialized investments which encourages internal product-market competition due to lack of integrative capability. Internal product competence inconsistence and realignment of optimal competences allocation discourage diversified firms to innovate and enhance potential for cannibalization. Specifically, organizations face risk of potential cannibalization effects between diversified product-markets and respond to this threaten through creative destruction.

Firms which diversify in different markets are reluctant to innovate due to potential cannibalisation effects derived from diseconomies of scope.

Hypotheses 1: "The higher the firm's level of business diversification, the lower will be the number of products introduced by the firm"

Literature of downstream diversification studies firm's resource base implications on technological search over time (Patel & Pavit, 1997; Silverman, 1999). However, technological search is not an isolated process and technological productivity depends on organizational ability to benefit from different knowledge combination landscapes.

First of all we need to understand the impact of downstream diversification in technological search strategy. Literature of strategic management of innovation distinguishes between scope of search innovation strategies, exploitation and exploration. Exploitation aims at refinement and extension of existing competences, technologies and paradigms, while exploration refers more specifically to learning or acquiring new knowledge and therefore innovation (March, 1991). Through exploration organizations can regenerate their existing knowledge and develop new capabilities to develop radical innovations (March, 1991; Gavetti & Levinthal, 2000; Nelson & Winter, 1982; Galunic & Rjordan, 1998; Fleming & Sorenson, 2001; Nerkar & Roberts, 2004; Miller, Fern, & Cardinal, 2007). In order to take a knowledge access decision, firms must balance costs and risks of both choices (Katila & Ahuja, 2002). Final choice will be constrained by the flexibility of current knowledge to adjust to new landscapes.

Organizational ability for knowledge recombination will rely on knowledge interdependence, as the functional sensitivity of a technology to changes in these constituent components (Fleming & Sorenson, 2001). Technological recombination will be easier in knowledge structures characterized by low levels of interdependences. High levels of knowledge diversification will imply low level of knowledge interdependence as long as diversified knowledge relies on different resource base. Therefore, diversified knowledge stock will encourage recombination due to changes made to one technology will not require change to another for its correct work. This large number of potential interconnections would encourage exploitation search strategy and innovations based on new technological elements allowing firms to penetrate into new landscapes. This argument is in line with the idea developed by Sorenson & Fleming (2001), who posit that "strong interdependences across knowledge elements involve the existence of local peaks which elude improvements through incremental search because altering any single element degrades the quality of the outcome".

Once we pointed out the impact of downstream diversification in search strategy, we analyze subsequently the final effect on technological productivity. Exploitative search strategy is going to allow for the emergence of technological spillovers related to technological and managerial know-how. Firms benefit from the use of incremental resources in different technological landscapes and generate search cost advantages across different diversified technologies and expand technological spillovers. The capacity to reduce cost of acquiring different technologies comes from the opportunity to share R&D expenses in each specialized domain, adapt previous design equipment to incremental technologies, reuse of quality systems, and exploit experiential know-how advantages in design and adoption of new knowledge. Organizations will be able to develop integrative capability in each knowledge domain and support the emergence of economies of scope due to cost advantages across diversified knowledge stock and benefits from knowledge spillovers.

Firms which diversify in different technological landscapes are willing to increase the adoption of new knowledge due to incremental technological spillovers and lower search cost derived from economies of scope.

Hypotheses 2: "The higher the firm's level of technological diversification, the higher will be the number of new patents of the firm"

Methods

Data and Sample

Our sample is composed by large companies because they operate in operate in different markets of products and technological landscapes with several overlaps. A second selection criterion is focusing on high tech sectors in which knowledge search and product innovation are core activities to generate competitive advantages.

We identify large companies through Fortune Global 500 2006. Fortune Global 500 2006, present the list of largest world companies classified into 52 sectors. Among these 52 sectors, we identify high tech sectors through Compustat database, looking for R&D overall sector expenses. The sectors selected are the following: aerospace and defense, chemicals, computer & office equipments, electronics & electrical equipment, motor & vehicle parts, pharmaceutical, semiconductors and telecommunications. The sample generates 693 observations on 99 companies classified into 8 different industries from 1999 to 2005.

Measures

Dependent variables

Product Introduction variable is related to firm's ability to market a new product from 1999 to 2005. We obtain the data through Info Trac Database. We search for all articles that reported the name of the company and the word “product introduction”. We extract the name of the company, and the date of product introduction. After this initial classification we compute the total number of products introduced yearly by firm.

Number of Patents variable is related to organizational ability to adopt new knowledge from 1999 to 2005. We extract the information through the United States Patent and Trademark Office (USPTO). We report the total number of patents of each firm from 1999 to 2005.

Independent variables

Business Diversification variable measures the degree of dispersion of the firm’s businesses. We build this measure according to C1 concentration index. C1 is the percentage of share held by the largest business by each firm. Firstly, for each firm from 1999 to 2005 we compute the number of trademarks in each business according to different USPTO international classification of goods and services. Then, we obtain the share of each business and we select the largest one. The index varies between 0 and 1. The lowest the index, the broader the scope of the organization business management, and therefore, the less likely it will be able to introduce new products. We understand this measure as a variation of Herfindhal index. The reason to rely on C1 index instead of Herfindhal index is due to the structure of available data. The estimation of concentration index across each international business classification implies the existence of large number of null trademarks values in non diversified firm’s markets. Therefore the large amount of null values in our dataset makes unreliable Herfindhal index measure.

Technological Diversification variable measures the degree of dispersion of the firm’s technological landscapes. As business diversification variable, we build this measure according to C1 concentration index. C1 is the percentage of share held by the largest technological landscape by each firm. Firstly, for each firm from 1999 to 2005 we compute the number of patents in each technological class according to different NBER US classification of patent. The file contains the original and cross-reference classes in which the patent was classified at the time of the most recent PTO Master Classification File. Then, we obtain the share of each technological class and we select the largest one. The index varies between 0 and 1. The lowest the index, the broader the scope of the organization technological landscapes, and therefore, the less likely it will be able to introduce new products. The broader the scope of organization’s technological expertise and therefore, the more likely it will be able to enter new technologies. Firms with a dispersed patent portfolio have learned to manage different technologies and therefore should display a greater ability to enter into a new technological field compared with firms endowed with a narrow technological portfolio (Laursen et al.2008). As we pointed out before, the selection of C1 instead of Herfindhal index, as diversification measure is related to data structure.

Control variables

In addition to the variables proposed to test the hypothesis, we also control for other factors suggested by diversification and innovation literature.

At the firm level, we matched the available information on company’s name and industry, with data on firm size measured by the logarithm of net sales drawn from Compustat database and proprietary or publicly-available data source, namely Thomson Research, Comp tech, Google Finance and, whenever necessary, company websites or other online available data sources.

R&D expenses control for the ability of each firm to invest on innovation activity. We can guess that the higher the intensity effort of the investment, the higher will be the willingness of the organization to develop product or technological innovations. We compute R&D expenses as percentage of sales volume to compare the effectiveness and efficiency of R&D expenditures between companies in the same industry. We extract data for all the companies from 1999 to 2005 through Compustat database.

Finally, we include three groups of dummy variables: nationality, the sector, and the year object of study. We have to control the nationality of the firm in order to realize about the influence of the firm's origin on the results. We define 12 dummy variables according to our firm's nationality (USA, UK, Canada, France, Japan, South-Korea, Netherlands, Germany, Sweden, Italy, Switzerland, and Spain). The second group of dummy variables controls for the sector characteristics to avoid the impact of industrial innovation capacity on the regression. We obtain 8 sector dummy variables according to the Fortune high tech sector's classification (aerospace and defense, chemicals, computer & office equipments, electronics & electrical equipment, motor & vehicle parts, pharmaceutical, semiconductors and telecommunications). Moreover we need to control for the year object of study to avoid the influence of macroeconomic trends such as economic cycles and periods of technological ferment that could affect technological and product innovations. Due to our analysis study run the gamut from 1999 to 2005, we have 7-year dummy variables.

Table 1 reports the descriptive statistics for our analysis. If we look at our core variables values in Table 1 we can see that on average, a firm introduces 2.64 new products by year, with a maximum value of 39 and a minimum value of 0. Looking at number of patents, firms accomplish on average 277.17 patents, with a maximum value of 2312 and 0 as the minimum. Our business diversification measure the mean for C1 concentration index is 0.24. On the other hand technological diversification reaches a mean value for C1 equal to 0.038.

Table 1. Descriptive Statistics

Variable	Obs	Mean	Std. Dev.	Min	Max	Product Intro	Number Patents	Business Diversification	Technological Diversification	R&D Expenses	Sales
Product Intro	693	2.64	4.83	0.00	39.00	1.00					
Number Patents	693	277.18	480.63	0.00	2312.00	0.40	1.00				
Business Diversification	693	0.24	0.20	0.00	1.00	0.15	0.14	1.00			
Technological Diversification	693	0.04	0.12	0.00	1.00	0.01	-0.01	0.20	1.00		
R&D Expenses	693	0.13	1.20	0.00	27.82	-0.01	0.06	-0.01	-0.01	1.00	
Sales	693	10.15	0.92	4.87	12.21	0.20	0.19	-0.24	-0.05	-0.32	1.00

Results

As our dependent variables are nonnegative count variables we use a negative binomial model, specifically negative binomial regressions. Table 2 reports the analysis of business and technological diversification on product introduction and knowledge search productivity, respectively.

Model 1 supports Hypothesis 1 for innovative productivity, as long as the number of upstream diversification would be higher, firms would reduce the number of new product introductions. On the other hand, technological diversification has a negative impact on firm´s ability for product innovation however it is not statistically significant. Finally, we find a positive and significant impact of impact of sales and R&D expenses in product introduction.

Model 3 tests Hypotheses 2, it focuses on the effect of downstream diversification in knowledge search productivity. We find support for the positive impact of technological diversification in the dependent variable. Moreover we find interestingly that business diversification impact positively in the number of patents, however it is not significant. Sales and R&D expenses result positively significant in the model. In this model due to data availability we control for missing technological diversification variable.

In order to go deeper on the analysis of upstream and downstream diversification and the organization innovative productivity we perform a simulation test to predict the behavior of our variables. We analyze the value of Product Introduction and Number of Patents dependent variable according to the value modification of the core variables (business diversification and technological diversification. Due to the index nature of our independent variables, we set a large index range between 0 and 1.

Table 2. Determinants of Innovative Productivity. Results of Negative Binomial Regressions.

	Product Introduction			Number Patents	
	Model 0	Model 1		Model 2	Model 3
Independent Variables					
Business Diversification	-	0.70** (0.31)		-	-0.05 (0.30)
Technological Diversification	-	-0.19 (0.34)		-	-0.89** (0.39)
R&D Expenses	0.11** (0.04)	0.12*** (0.04)		0.13*** (0.04)	0.13*** (0.04)
Sales	0.44*** (0.05)	0.47*** (0.06)		0.26*** (0.06)	0.24*** (0.06)
Dummy Sector			Yes		
Dummy Nationality			Yes		
Dummy year			Yes		
Number of obs	693	693		693	693
Wald chi2(30)	2484.34	2522.8		2086.77	2016.01
Prob>chi2	0	0		0	0

One-tailed *t*-test applied. * p < 0.10; ** p < 0.05; *** p 0.01

Then we rely in our final negative binomial model to perform a prediction. In this way, we obtain two tables according to modification of value core variables.

The first table predicts the average of Product introduction according to modification of business diversification and technological diversification measures. We find that higher values of product introduction (0.70) are associated to highest value of upstream diversification (1) and lowest downstream diversification value (0). However, high values of technological and low levels of business diversification deter firm’s capability to introduce new products (-0.19).

On the other hand, second table refers to firm´s ability to adopt new knowledge taking into account diversification variables modification. Interestingly the highest value of number of patents is related to lowest levels of downstream and upstream diversification (4.71). The lowest value of number of patents rises with maximum levels of diversification (3.78).

Due to the count data nature of our sample, we perform a robustness test by the application of a generalized negative binomial model to obtain a reliable relationship between organizational diversification and organizational innovative productivity. Generalized negative binomial regression is a generalization of the negative binomial model in which the shape parameter itself is parameterized (predicted).

The data in our sample comes from 99 different firms. It is conceivable that the shape parameter could be different depending on the firm. The generalized negative binomial model application verifies previous negative binomial results.

First, looking at product introduction regression, in Model 1, we find that the development of upstream diversification has a negative influence on organizational capacity to introduce new products. On the other hand, technological diversification does not have a significant effect in the model.

Table 3. Simulation Test in the R&D Contractual Agreements- Product diversification Relationship

	Technological Diversification					
Business Diversification	**0**	**0.20**	**0.40**	**0.60**	**0.80**	**1**
0	0.00	-0.04	-0.07	-0.11	-0.15	-0.19
0.20	0.14	0.10	0.07	0.03	-0.01	-0.04
0.40	0.28	0.24	0.21	0.17	0.13	0.10
0.60	0.42	0.38	0.35	0.31	0.27	0.10
0.80	0.56	0.52	0.49	0.45	0.41	0.38
1	0.70	0.66	0.63	0.59	0.55	0.52

	Technological Diversification					
Business Diversification	**0**	**0.20**	**0.40**	**0.60**	**0.80**	**1**
0	4.71	4.53	4.36	4.18	4.00	3.83
0.20	4.70	4.52	4.35	4.17	3.99	3.82
0.40	4.69	4.51	4.34	4.16	3.98	3.81
0.60	4.68	4.50	4.33	4.15	3.97	3.80
0.80	4.67	4.49	4.32	4.14	3.96	3.79
1	4.66	4.48	4.31	4.13	3.95	3.78

Second, Model 2 verifies previous negative binomial model results in firm´s ability to adopt new knowledge. This model shows that downstream diversification remains positively significant in knowledge search productivity. However, as obtained in our original model, business diversification does not have a significant influence on the number of patents.

Discussion

This paper started by observing that literature in organizational innovation has been mainly focused on firm´s ability to identify and combine core competences to develop technological or product innovations. Research has not explored the implications of business and technological landscapes dispersion in organizational innovative productivity. Our purpose is to understand the impact of upstream and downstream diversification in firm´s ability to introduce new products and adopt new knowledge.

First, we explore a negative relationship between upstream diversification and product introduction. In the empirical test we apply a negative binomial model to test our hypotheses. We find that business dispersion deters firm´s ability to introduce new products. Interestingly, downstream diversification does not have a significant impact in the introduction of new products.

Our explanation is that motivation for product commercialization depends on firm´s ability to keep its current market power and core business position. As long as firm´s increases the level of markets dispersion, the risk of product cannibalization will discourage firms for product introduction due to firm´s inability to develop economies of scope and compatible technological spillovers.

Second, we look at downstream diversification and knowledge search productivity association. We stated the second hypotheses related to the positive impact of technological diversification in firm´s ability to adopt new knowledge.

Table 4. Robustness test. Results of Generalized Negative Binomial Model

	Product Introduction		Number Patents
	Model 1		Model 2
Independent Variables			
Business Diversification	0.88***		-0.01
	(0.32)		(0.31)
Technological Diversification	-0.27		-0.91**
	(0.35)		(0.39)
R&D Expenses	0.12***		0.13***
	(0.04)		(0.04)
Sales	0.48***		0.24***
	(0.06)		(0.06)
Dummy Sector		Yes	
Dummy Nationality		Yes	
Dummy year		Yes	
Number of obs	693		693
Wald chi2(30)	1987.83		2034.73
Prob>chi2	0		0

One-tailed *t*-test applied. * p < 0.10; ** p < 0.05; *** p < 0.01

Results reveal that dispersion of technological landscapes would encourage the acquisition of new patents. To understand this positive relationship, it is necessary to take into account the implications of current organizational knowledge configuration. Organizational knowledge integration reflects the strength of knowledge interdependences and thus, its recombination capacity. High rates of knowledge diversification, implies firm´s reliance on different technological landscapes, and subsequently low level of knowledge interdependence. The ability to recombine different technological sources will allow companies to benefit from economies of scope and incremental technological spillovers. Firms will take advantage from this profitable situation by the adoption of new patents.

This study deepens our understanding of organizational innovation in diversified firms. We analyze innovative productivity from a new perspective realizing about organizational diversification conditions. In particular, our research builds a new innovative pattern taking into account upstream and downstream diversification. We have defined a new role of business and technological landscapes dispersion in firm´s capacity to introduce new products and adopt new knowledge. Furthermore, we explore the different impact of market and technological diversification in product commercialization and knowledge productivity. The novelty of this study implies a huge unexplored field to go deeper on diversification and innovation research. Future research could enlarge organization innovative perspective. This would allow us to differentiate between other innovative features not related with the number of product, number of patents. It would be interesting to enlarge the organizational diversification by the introduction of markets derived from different technological agreements. The conciliation of both schemes can be source of multiple studies in different management fields.

Several implications for managers arise from this research. First, managers in high-tech environments have to examine and evaluate diversification alternatives to develop a productive innovative strategy. Managers must differentiate between different sources of diversification due to its different impact on innovative productivity. Second, managers who decide to diversify into new markets cannot obviate the organizational risk of product cannibalization, it is necessary to analyze jointly the development of different products and its final impact of firm´s market power. Finally, to understand how downstream diversification allows firms to adopt new knowledge, the study of potential knowledge recombination is crucial to obtain a reliable forecasting.

Besides contributing to product diversification theory we have challenged its empirical validation. Our novel sample is based on large multinational companies, which play in high innovative environments. We have built an original panel dataset for 99 Fortune high-tech companies from 8 different industries from 1999 to 2005. We acknowledge that, that interpreting the complex interactions among diversification, product introduction and knowledge search productivity, is a very difficult task, future research could focus on further scrutiny, possibly based on in-depth case studies.

Nevertheless, we believe that this paper is an important first attempt at better understanding how organizational diversification helps firms to develop a productive innovation strategy.

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INDEX